Essays on Firm Dynamics

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A mis padres, María José y Javier, y a mi hermana, Elena, mis pilares en la vida...

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Abstract

There is a growing interest among macroeconomists in incorporating explicit heterogeneity into macroeconomic models, allowing to bring in micro data to discipline them. In this way, we can understand how shocks or policies impact differently these heterogeneous agents and their macroeconomic implications, which sometimes might differ from those obtained using a representative agent model. My dissertation consists of two main chapters that attempt to understand the impact of changes in the economic environment, with a special focus on taxes, on heterogeneous firms' investment and growth decision, the firm size distribution of firms, and ultimately their impact on macroeconomic aggregates.

In the first chapter, '*Taxation and the Life Cycle of Firms*', co-authored with Andrés Erosa, we extend the Hopenhayn and Rogerson (1993) framework to understand how different forms of taxing capital income affect firms' investment and financial policies over their life cycle. Relative to dividends and capital gains taxation, corporate income taxation slows down firm growth over the life cycle by reducing after-tax profits available for reinvesting. It also diminishes entry by negatively affecting the value of entrants relative to that of incumbent firms. After a tax reform eliminating the corporate income tax in a revenue neutral way, output and capital increase by 12% and 32%. The large response of firm entry is crucial for these results.

In the second chapter, '*Macroeconomics, Firms Dynamics and IPOs*', I study how changes in the economic environment witnessed in the US in the last decades regarding taxes, access to credit and idiosyncratic productivity shock process impact firms' choices. I argue these changes might impact differently privately held and publicly traded firms, having therefore implications for the endogenous decision to become public (IPO) and their macroeconomic consequences. I extend a model of firm dynamics with private and publicly traded firms, where I explicitly model the going public decision. Firms are born private, grow by reinvesting profits and/or borrowing, and can eventually do an IPO and become public. Being public, firms can access to costly equity financing, but have to pay an ongoing cost of operation. I calibrate the model to the US, and study how the observed changes in the last decades of taxes, equity issuance costs, the costs of being public, access to credit and idiosyncratic shock process impact a) changes in selection into public (IPO); b) firms' policies; and c) macroeconomic aggregates. I find the decrease in corporate and dividend taxes in the 1990s contributes to the increase in share of public firms, and the changes in firms' policies observed in the data, having a larger impact than changes in equity issuance costs. An increase in the cost of being public is at odds with the changes in selection into public and firms' policies observed in the data during the 2000s, and so is an increase access to credit. Changes in the idiosyncratic shock process can reconcile some of the trends in behaviour and selection of publicly traded firms, and have important macroeconomic implications.

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Chapter 1

Taxation and the Life Cycle of Firms

1.1 Introduction

The macroeconomic effects of the taxation of capital income have received a great deal of attention by economists and policy makers. Throughout modern economies the taxation of capital income takes many different forms: capital gains taxation, interest income taxation, dividend taxation, and corporate income taxation. In particular, the tax rate on corporate income in the US was until recently among the highest of OECD countries, and this has raised concerns about its effects on job creation and investment. Policy advisors from the Obama and Trump administrations have advocated for changes in the taxation of capital income and, indeed, the Trump administration has recently cut by nearly half the corporate income tax rate. In this paper, we study how different forms of taxing capital income affect investment and financing decisions of firms over their life cycle, as well as the creation of new firms (firm entry), aggregate capital accumulation and output. We then evaluate the effects of a tax reform that eliminates the tax on corporate income and replaces the lost revenue with a common tax rate on all other form of capital income.

Corporate profits distributed as dividends suffer from the so-called 'double taxation', since they are taxed both at the corporate and the personal income level (by the corporate income tax and the dividend tax, respectively). The literature has long emphasized that corporate income taxation diminishes investment by firms by reducing the after tax return on capital. In this paper, we show that these distortions are much more severe when firms' growth over the life cycle is constrained by financial frictions. The impact of dividend taxation on firm investment decisions critically depends on the stage that firms are at in their life cycle, as young firms are more likely to issue equity while old firms are more likely to issue dividends. Young firms behave according to the 'traditional view' in the finance literature: an increase in dividend taxation raises the cost of external equity financing, negatively affecting firms' investment[1]. However, as emphasized by the 'new view' in the finance literature, dividend taxation does not affect investment decisions of firms distributing dividends (mature firms), since the dividend tax leads to an equiproportional reduction in the return and costs of investment. More generally, our paper stresses that the various ways capital income can be taxed (whether corporate income, dividend, or capital gains taxation) have quite different effects on investment and payout policies over the life cycle of firms, and hence on the life cycle growth of firms. They also have different and asymmetric effects on the market valuation of new versus incumbent firms, and thereby on firm entry.

Our paper is motivated by micro evidence on firm dynamics and the life cycle of firms. Haltiwanger et al. (2013) argue that start ups play a critical role for understanding US employment growth dynamics. The mass of firms entering the economy is large, most new businesses start as small but (conditional on survival) grow fast, and new entrants are important for understanding employment growth. Moreover, Hsieh and Klenow (2009) argue that the cross country differences in the life cycle growth of firms are important for understanding aggregate productivity differences across countries. The evidence indicates that firms face substantial equity issuance costs (see Hennessy and Whited (2007), Lee et al. (1996)). Using micro evidence from US and UK firms, Cloyne et al. (2018) show that financial frictions affect more strongly investment decisions of young firms than that of mature firms. Campbell et al. (2013) empirically document heterogeneous investment responses across young and mature firms after the reduction on shareholder taxes in the US in 2003. Becker et al. (2013) study many tax reforms on 25 countries over a 20 year period, finding that changes in payout taxes affect firms differently depending on their financial regime. Overall, this evidence points to the importance of modeling the life cycle of firms for assessing the effects of taxation. A model with a representative firm, as in the standard Neoclassical Growth Model, implicitly focuses on mature firms (i.e. those distributing dividends where the 'new view' holds), disregarding the evidence that investment responses to tax changes vary over the life cycle of firms. Moreover, the empirical findings of Haltiwanger et al. (2013) suggest that it is important to consider the impact of taxation on business entry.

We extend the Hopenhayn and Rogerson (1993) framework of firm dynamics to understand how different forms of taxing corporate income affect the life cycle of firms. We start by analysing a simple version of the model with a deterministic fixed level of productivity determined upon entry. Companies need to raise equity to set the firm up, starting their life in the 'traditional view' regime (equity issuance phase). They grow by accumulating profits (growing phase), until they reach their optimal size and start distributing dividends (matu-

[1] See, for instance, (Auerbach, 2002) for a description of these views.

rity phase). Consistent with the 'new view', dividend taxation does not distort investment decisions and dividends paid by mature firms. However, dividend taxation diminishes the optimal amount of initial equity issued by firms. Intuitively, firms can diminish the taxes paid by financing a larger portion of investments with retained earnings. Hence, dividend taxation reduces the initial size of firms, retarding the age at which they reach maturity, and diminishes entry. The taxation of capital gains has the opposite effects of dividend taxation. First, the taxation of capital gains encourages firms to issue more equity at entry in order to avoid paying the taxes that would accrue with the accumulation of internal funds. Second, it distorts the optimal scale of the firm at maturity. Corporate income taxation impacts on capital accumulation through several channels. First, corporate income taxation distorts the optimal size and dividends paid by mature firms by decreasing the return on capital. Second, crucial to our analysis and results, the corporate income tax decreases after-tax earnings, making it harder for firms to finance investment with retained earnings and causing firms to grow at a slower pace over their life cycle. As a result, the market value of the firm decreases, leading to two additional effects of corporate income taxation on capital accumulation: firms raise less equity at entry, and the equilibrium mass of entry becomes smaller. While these effects are also present under dividend taxation, they are stronger under corporate income taxation.

The baseline economy with firm dynamics (due to idiosyncratic productivity shocks at the firm level) is calibrated to moments on the micro data on firms' investment and financing decisions. We use the calibrated model economy to quantitatively assess the effects of a reform that eliminates the taxation of corporate income while keeping constant the tax revenue collected on capital. This is done by finding the common tax rate (τ) on all forms of capital income (dividends τ_d, interest income τ_r, and capital gains τ_g) that collects the same tax revenue as in the baseline economy. The purpose of the proposed policy reform is twofold. Firstly, all sources of capital income are treated symmetrically from the household perspective. Secondly, by eliminating the corporate income tax, financially constrained firms are able to accumulate profits and to reach maturity (the dividend distribution stage) faster. The elimination of the corporate income tax in the baseline economy ($\tau_c = 0.34$) should be accompanied by an increase in the other capital income tax rates to 0.41 in order to keep government revenue constant (the dividend and capital gains tax in the baseline economy were set to 0.15 and the interest income tax was set to 0.25). In equilibrium, this leads to an increase in the initial size at entry, a decrease in the optimal size at maturity, and a decrease in the time to reach maturity. This benefits mostly young firms, thereby increasing entry by 35%. Aggregate output increases 12%, accompanied by a large increase in the aggregate capital stock (32%). Hence, the large response of firm entry is important for understanding the macroeconomic effects of the tax reform. When entry is kept fixed, the increase in output is a third and the rise in capital is half of those in the economy with endogenous entry.

At the heart of our results is the fact that the tax reform increases the expected value at entry more than the value of incumbent firms, leading to a reallocation of resources from mature to younger firms, which operates through an increase in entry and in the equilibrium wage rate. The elimination of corporate income taxation allows financially constrained firms to retain a larger fraction of their earnings and increase their investments. The ability to retain earnings is particularly relevant for young firms, which are more likely to be constrained than the average incumbent firm in the economy. Since the value at entry is determined by the average value of age-0 firms, the value of the average firm entering the economy increases more than that of incumbent firms when corporate income taxation is eliminated. In general equilibrium, the increase in the value of entry requires the wage rate to rise, which reduces labor demand by incumbent firms. Labor market clearing requires a larger mass of firm entry, which rises by about 35%. Larger firm entry, together with a reallocation of resources to financially constrained firms, lead to an increase in aggregate TFP of 4.6%.

Our model economy builds on Gourio and Miao (2010), who study the impact of dividend taxation on firms' investment and payout decisions. We contribute by comparing alternative forms of capital income taxation and by extending their analysis to incorporate three key features for our results: life cycle (endogenous entry), financial frictions, and corporate income taxes. In particular, we emphasize the importance of the life cycle of firms for understanding how taxation affects investment incentives of firms. Korinek and Stiglitz (2009) build a theory of the life cycle of firms for understanding the impact of dividend taxation but abstract from corporate income taxation and firm entry. McGrattan and Prescott (2005) and Atesagaoglu (2012) study how corporate income taxation affects the market valuation of firms in environments with a representative firm. Conesa and Domínguez (2013) advocate for the elimination of corporate income taxation in a Ramsey optimal taxation exercise with a representative firm, with no financial frictions and no firm entry/exit. Similar to us, Anagnostopoulos et al. (2015) evaluate the gains of eliminating corporate income taxation in a model with firm heterogeneity and household heterogeneity. We abstract from household heterogeneity but contribute by focusing on firm entry and the life cycle of firms, which turn out to be key for the large quantitative effects of our tax reform, and which Haltiwanger et al. (2013) emphasize as crucial for understanding the dynamics of employment growth in the US. The financial crises has sparked great interest in the literature analyzing the role of financial frictions in business cycle fluctuations. Papers in this literature include Cooley and Quadrini (2001), Khan and Thomas (2013), Jermann and Quadrini (2012) (among many others). Our results suggest that the design of capital income taxation may affect the propagation of business cycle shocks.

An outline of the paper follows. Section 2.3 presents and analyzes a simple version of our baseline model economy in which firms do not face idiosyncratic shocks to their productivity, in order to illustrate how different forms of taxing capital income affect investment and payout policies over the life cycle of firms, the value of firms to its shareholders, and firm entry. Section 1.3 presents our baseline model economy of firm dynamics and taxation of capital income, and shows the calibration and our main quantitative exercises. Section 1.4 concludes[2].

1.2 A Simple Deterministic Model Economy

Our baseline model extends the Hopenhayn and Rogerson (1993) framework of firm dynamics to study taxation of corporate capital income. Time is continuous[3]. Each firm may exit the economy with some fixed probability. The entry of new firms is endogenous. Firms can finance investment with retained profits or equity issuance. Firms face adjustment costs in capital. Following Cooley and Quadrini (2001) and Gomes (2001), firms face financial frictions, since equity issuance is costly. There is a representative household that owns all firms. There is a large number of firms so that the representative consumer does not face any uncertainty. As in Gourio and Miao (2010), households pay taxes on dividends (τ_d), interest income (τ_r), and capital gains taxes (τ_g)[4]. In addition, corporations pay taxes on corporate profits (τ_c), so that capital income is taxed both at the firm and household level.

In this section, we illustrate the key ideas of our paper in a deterministic version of our baseline model economy that abstracts from adjustment costs in capital.

1.2.1 The problem of a firm

When firms are created, they draw a productivity z that stays fixed over the lifetime of a firm. Firms exit exogenously the economy at a rate δ_d. The economy is a steady state with an after tax interest rate equal to $r(1-\tau_r) = \rho$, where ρ is the rate of time preference of the representative household (investor).

[2] Appendix D evaluates the sensitivity of the results to alternative formulations of entry decisions, the shock process faced by firms, and to incorporating an endogenous labor supply choice.

[3] Achdou et al. (2017) and Barczyk and Kredler (2014) advocate the use of continuous time models for analyzing heterogeneous agent models. We extend their methods to a model of firm dynamics with financial frictions.

[4] While in the US capital gains are taxed upon realization, we follow standard practice in the literature by modeling capital gains taxation on an accrual basis. This modeling choice simplifies the analysis considerable and allow us to derive our results in a more transparent way.

Each firm produces output with a decreasing returns to scale production function in capital and labor inputs: $f(z,k,n) = z^{1-\alpha-\eta}k^{\alpha}n^{\eta}$. Profits are given by

$$\pi(z,k) = \max_{n}\{f(z,k,n) - wn - \delta k\}.$$

The flow constraint is

$$\dot{k} = (1-\tau_c)\pi(z,k) - d + (1-\xi)e,$$

where d and e denote dividend distribution and equity issued by firms. We assume that equity issuance is costly. There is a cost ξ per unit of equity issued, so the resources available are $e(1-\xi)$.

Consider a firm with fixed z. The market value (V), the dividends paid (d), and the equity issued (e) are deterministic functions of the age of the firm t. However, these variables are not explicitly indexed with a subscript t to simplify the notation (unless there is some risk of confusing the reader). Taking as given investment and financial policies, the market value of the firm V is such that the after tax rate of return on equity equals the investor rate of discount ρ:

$$\rho = \frac{d(1-\tau_d) + (1-\tau_g)(\dot{V} - e - \delta_d V)}{V} \tag{1.1}$$

where $\dot{V}$ represents the rate of change of V with respect to time (age of the firm). Note that increases in share values due to equity issuance are not taxable. Firm exit gives rise to negative capital losses that are tax deductible. The above non-arbitrage equation can be re-arranged as

$$\left(\frac{\rho}{1-\tau_g} + \delta_d\right)V = \frac{1-\tau_d}{1-\tau_g}d - e + \dot{V}.$$

The solution to this first-order linear differential equation on V gives the integral in (1.2). Note that the path of dividends in this integral is multiplied by the ratio $\frac{1-\tau_d}{1-\tau_g}$, which follows from the interplay of two opposite effects of the taxation of dividends and capital gains. The numerator is explained by the fact that investors receive a fraction $1-\tau_d$ of the dividends distributed by the firm. The denominator is explained by the fact that when firms retain earnings (do not distribute dividends) the value of the firm increases and this capital gain is subject to the tax τ_g. In addition, the rate at which firms discount future dividends $(\frac{\rho}{1-\tau_g} + \delta_d)$ increases with the capital gains tax rate. Intuitively, dividend growth raises the value of the firm over time and these changes in market value are taxed at a rate τ_g.

The problem of the firm in state (z, k) is then to choose investment and financial policy to maximize:

$$V(z,k) \equiv \max \int_0^\infty e^{-(\frac{\rho}{1-\tau_g}+\delta_d)t} \left\{ \frac{1-\tau_d}{1-\tau_g} d - e \right\} dt \tag{1.2}$$

subject to:

$$\dot{k} = (1-\tau_c)\pi(z,k) - d + (1-\xi)e$$

$$d \geq 0, e \geq 0, k_0 \text{ given.}$$

Associate the present-value multipliers $e^{-(\frac{\rho}{1-\tau_g}+\delta_d)}\lambda_t$ to the flow of funds constraint, $e^{-(\frac{\rho}{1-\tau_g}+\delta_d)}\mu_t^e$ to the non-negativity constraint on equity issuance, and $e^{-(\frac{\rho}{1-\tau_g}+\delta_d)}\mu_t^d$ to the non-negativity on dividend distribution. Then, the FOC from the Maximum Principle imply:

$$\lambda = \frac{1-\tau_d}{1-\tau_g} + \mu^d \tag{1.3}$$

$$(1-\xi)\lambda + \mu^e = 1 \tag{1.4}$$

$$\lambda \left[\frac{\rho}{1-\tau_g} + \delta_d - (1-\tau_c)\pi'(z,k) \right] = \dot{\lambda} \tag{1.5}$$

$$\dot{k} = (1-\tau_c)\pi(z,k) - d + e(1-\xi) \tag{1.6}$$

$$\mu^d \geq 0, \ d \geq 0, \ \mu_t^d d = 0 \tag{1.7}$$

$$\mu^e \geq 0, \ e \geq 0, \ \mu_t^e e = 0 \tag{1.8}$$

$$\lim_{t\to\infty} e^{-(\frac{\rho}{1-\tau_g}+\delta_d)t}\lambda_t k_t = 0 \text{ (Transversality)} \tag{1.9}$$

Conditions (1.3) and (1.7) imply that the shadow value of funds $\lambda \geq \frac{1-\tau_d}{1-\tau_g}$, with equality if dividends are strictly positive. Conditions (1.4) and (1.8) imply that the shadow value of funds $\lambda \leq \frac{1}{1-\xi}$, with equality if equity issuance is strictly positive. In sum, the shadow value of funds satisfies $\lambda \in \left[\frac{1-\tau_d}{1-\tau_g}, \frac{1}{1-\xi}\right]$.

1.2.2 Entry, optimal initial equity, and time to maturity

As in Hopenhayn and Rogerson (1993), firms pay a fixed cost c_e to draw a productivity z from an exogenous probability density g_e. The firm decides the initial amount of capital $k_0(z)$ after observing the productivity draw z. The value of entry is then given by

$$V^e = \int_0^\infty V(z, k_0(z)) - \frac{1}{1-\xi} k_0(z) g_e(z) dz = c_e, \tag{1.10}$$

where the second equality states that in a steady state equilibrium the value of entry should be equal to the entry cost. The wage rate adjusts to ensure that this is the case. The mass of firms entering the economy is determined by the labor market clearing condition:

$$\int_0^\infty n(z,k)g(z,k)dzdk = 1, \text{where } g \text{ satisfies} \tag{1.11}$$
$$0 = -\partial_k\left(s(z,k)g(z,k)\right) - \delta_d g(z,k) + M g_e(z) I_{k=k_0(z)},$$

where $n(z,k)$ denotes the optimal labor demand, $\dot{k} = s(z,k)$ is the optimal investment in capital, and $g(z,k)$ the mass of firms in state (z,k).

Consider a firm with productivity z that raises capital (equity) k_0 when newly created. The firm will accumulate capital until it reaches the optimal amount of capital $k^*(z)$. Once the firm reaches its optimal scale, it distributes dividends until it dies. The age (T) at which the firm starts distributing dividends solves the following equation:

$$(1-\tau_c)\int_0^T \pi(z,k_t)dt + k_0 = k^*. \tag{1.12}$$

The above equation defines an implicit function $T(z,k_0)$ characterizing the age when a firm matures (starts distributing dividends) as a function of its net worth at entry (age 0). Since an increase in initial capital k_0 increases the profits accumulated by the firm over time, the firm takes a shorter period to reach maturity. Formally, differentiating (1.12) with respect to initial capital k_0 yields

$$\frac{dT}{dk_0} = -\frac{1+(1-\tau_c)\int_0^T \pi'(z,k_t)\frac{dk_t}{dk_0}dt}{(1-\tau_c)\pi(z,k_T)} < 0. \tag{1.13}$$

In words, if initial capital k_0 is greater, everything else held constant, the time to reach maturity decreases.

We now focus on determining the optimal amount of initial equity. For a fixed value of k_0, T is computed from (1.12). Equations (1.3)- (1.7) imply that the shadow value of funds at age T satisfies $\lambda(T) = \frac{1-\tau_d}{1-\tau_g}$. Integrating (1.5) between 0 and $T(k)$ gives

$$\lambda(0) = \frac{1-\tau_d}{1-\tau_g} e^{\int_0^T \left[(1-\tau_c)\pi'(z,k_t) - (\frac{\rho}{1-\tau_g}+\delta_d)\right]dt}. \tag{1.14}$$

The function inside the integral in (1.14) has a positive sign for all $t < T$, is equal to 0 at T, and is decreasing in k_0 (due to decreasing returns to capital accumulation). Moreover, T is a decreasing function of k_0 . As a result, it is easy to see that $\lambda(0)$ is a decreasing function of k_0. The optimal value of initial equity is obtained by solving $\lambda(0) = 1 + \xi$.

The value of a firm with initial capital (equity) k_0 satisfies

$$V(z, k_0) = \int_{T(k_0,z)}^{\infty} \frac{1-\tau_d}{1-\tau_g} e^{-(\frac{\rho}{1-\tau_g}+\delta_d)t} d^*(z)dt = \frac{1-\tau_d}{1-\tau_g} d^*(z) \frac{e^{-(\frac{\rho}{1-\tau_g}+\delta_d)T(z,k_0)}}{\frac{\rho}{1-\tau_g}+\delta_d}. \tag{1.15}$$

Note that another way of solving for the optimal amount of initial equity is

$$\max_{k_0} V(z, k_0) - \frac{1}{1-\xi} k_0, \tag{1.16}$$

which implies

$$V'(z, k_0) = \frac{1-\tau_d}{1-\tau_g} d^*(z) e^{-(\frac{\rho}{1-\tau_g}+\delta_d)T(z,k_0)} (-1) \frac{dT}{dk_0} = \frac{1}{1-\xi}. \tag{1.17}$$

Since V is a concave function of capital, it follows that the solution for initial equity is unique.

1.2.3 The life cycle of a firm

The previous discussion highlights that, as in Korinek and Stiglitz (2009), firms in our simple model face three distinct phases during their life cycle: equity issuance phase, growth phase, and dividend distribution phase.

- **Equity issuance phase.** The first stage occurs when firms are created. Firms start with zero net worth. In order to operate they need to raise equity at age 0 so that $e_0 > 0$. The Kuhn Tucker complementarity slackness condition (1.8) implies that $\mu_0^e = 0$ so that (1.4) implies that the shadow value of assets at age 0 is given by $\lambda_0 = \frac{1}{1-\xi}$. The non-negativity constraint on dividend distribution binds ($\mu_0^d > 0$) so that firms do not distribute dividends. The amount of initial equity raised is such that:

$$(1-\tau_c)\pi'(z, k_0) > \frac{\rho}{1-\tau_g} + \delta_d \tag{1.18}$$

  By equation (1.5), once the firm is set up and $\lambda_0 = \frac{1}{1-\xi}$, the next instant the value of the multiplier is decreasing, i.e. $\lim_{t\to 0^+} \lambda_t < \frac{1}{1-\xi}$. Otherwise, condition (1.18) implies that $\lim_{t\to 0^+} \lambda_t > \frac{1}{1-\xi}$, which violates the non-negativity of μ_t^e (see equation (1.4)). This phase would fall within the so-called 'traditional view', where firms are using equity issuance as the marginal source of financing.

- **Growth phase.** When firms start operation (immediately after age 0), the continuity of λ_t together with (1.18) imply that the shadow value of net worth decreases since $(1-\tau_c)\pi'(z,k_t) > \frac{\rho}{1-\tau_g} + \delta_d$ for $t > 0$ in the right neighborhood of $t = 0$ ($\dot{\lambda_t}$). Newly created firms start operating and retain earnings in order to increase their capital. As capital grows, the shadow value of funds decreases, relaxing the non-negativity constraint on dividends (its multiplier decreases).

- **Dividend distribution phase.** Firms reach the dividend distribution phase (maturity) when the shadow value of funds reaches the value $\frac{1-\tau_d}{1-\tau_g}$. At this stage, the marginal source of funds is retained earnings, and its marginal cost equals the marginal benefit of distributing dividends. Growth ceases when firms reach a steady state with a constant capital (k^*) and constant dividend distribution d^* satisfying

$$(1-\tau_c)\pi'(z,k^*) = \frac{\rho}{1-\tau_g} + \delta_d \tag{1.19}$$

$$(1-\tau_c)\pi(z,k^*) = d^* \tag{1.20}$$

1.2.4 Discussion on taxation and the life cycle of firms.

We now discuss, for a fixed wage rate, the effects of taxes on the life cycle of firms. Equations (1.19) and (1.20) determine the optimal level of capital (k^*) and dividends (d^*) by mature firms. The value of a mature firm with productivity z is

$$V^{mature}(z) = \frac{1-\tau_d}{\rho + \delta_d(1-\tau_g)} \; d^*. \tag{1.21}$$

Using (1.15), the value of an age-0 firm with productivity z satisfies

$$V^{new}(z) = \underbrace{\frac{1-\tau_d}{\rho + \delta_d(1-\tau_g)} \; d^*}_{V^{mature}(z)} \; e^{-(\frac{\rho}{1-\tau_g}+\delta_d)T(z,k_0)} \tag{1.22}$$

The value of a new firm is a fraction of the value of a mature firm and that fraction decreases with the time it takes to reach maturity. Below we use (1.19)-(1.22) to evaluate the impact of capital income taxation on mature firms and on the market value of mature firms relative to that of age-0 firms.

Dividend taxation (τ_d) The tax rate on dividend distribution does not affect equations (1.19) and (1.20). It is then immediate that dividend taxation has no impact on capital and dividends paid by mature firms, a result consistent with the "new view" of the public finance literature. When the firm is indifferent between using its marginal unit of funds as dividend or investment, a change in the dividend tax rate has proportional effects on the benefits and cost of investment. As a result, investment decisions and dividend payouts of mature firms are unaffected by the dividend tax rate. However, the dividend tax reduces the market value of mature firms (it changes proportionally with the term $1 - \tau_d$, as shown in (1.21)).

Paradoxically, the dividend tax rate affects capital accumulation when firms are not paying dividends. This is because the lower value of the firm to shareholders reduces the optimal amount of initial equity (see equation (1.17)), retarding the age at which firms reach maturity. Intuitively, the firm can effectively diminish the taxes paid by reducing (initial) equity issuance and by financing investment with retained earnings. The fact that the firm reaches maturity at a later age, implies that dividend tax rate decreases the market value of firms at entry more than at maturity (in (1.22) the increase in T caused by dividend taxation further reduces the value of entry).

In sum, while dividend taxation does not distort the optimal scale and payouts of mature firms, it distorts the initial scale of operation of firms, diminishing capital accumulation along the life cycle and the age at which firms reach maturity. Moreover, dividend taxation affects assymmetrically the market value of mature firms versus that of entrants which, in general equilibrium, will negatively affect the creation of businesses (entry).

Taxation of capital gains (τ_g) The taxation of capital gains (τ_g) increases the cost of equity financing ($\frac{\rho}{1-\tau_g}$), reducing capital and dividend distribution of mature firms (see equations (1.19) and (1.20)). The decrease in dividends implies a decrease in the market value of mature and young firms[5]. The capital gains tax has two opposite effects on the initial capital of firms. On the one hand, when capital gains tax increases, the return on holding firms' shares needs to increase to satisfy the non-arbitrage condition. Since technology features decreasing returns, this is attained by reducing the optimal size of the firm. This, in turn, reduces the optimal initial size. On the other hand, the capital gains tax stimulates equity issuance at entry by increasing the rate at which future dividends are discounted (note that $\frac{\rho}{1-\tau_g} + \delta_d$ increases with τ_g). Intuitively, by raising more equity at entry, firms avoid paying taxes on capital gains that would accrue with the accumulation of internal funds.

[5]Note that τ_g enters in the denominator of (1.21). This expression represents the fact that the market value of mature firms increase with τ_g because the tax code in our model economy allows for a tax credit associated to the death of the firm. Quantitatively, this effect will likely have a small effect on the market value of firms if the death rate is small. As a result, we should expect the market value of mature firms to move together with d^*. This is always the case if we assume that there is no tax credit associated to the capital losses upon death of firms.

Note that this result is the opposite of what we found for dividend taxation.[6]

Corporate income taxation (τ_c) Corporate income taxation reduces capital accumulation and dividends paid by firms. Intuitively, corporate income taxation reduces the after tax benefit to capital (see left hand side of equation (1.19)) but without reducing the cost of funds to the firm. This effect reduces the optimal size (k^* decreases) and distributions (d^*) by mature firms (see equation (1.20)). Lower dividends imply a decrease in the market value of mature firms (see equation (1.15)) which, in turn, decreases the optimal amount of initial equity (equation (1.17)). Hence, firms start their life with a smaller scale. Moreover, the firm grows at a slower pace since the corporate income tax reduces the fraction of earnings that the firm accumulates during its growth phase in the life cycle (see equation (1.12)). The time to reach maturity may increase or not with corporate income taxation since there are two opposite forces at work: while firms grow more slowly, their optimal scale is smaller. In our computational experiments, the first effect is stronger so that firms take a longer time to mature.

It is important to note that the decrease in d^* associated with corporate income taxation reduces proportionally the market value of firms at entry and at maturity. In addition, for a fixed amount of initial equity, the corporate income tax makes it harder for firms to accumulate retained earnings, retarding the age at which firms reach maturity. This additional effect implies that corporate income taxation affects more negatively the market value of firms at entry than at maturity. The asymmetric effect on market valuations at entry and at maturity implies that the corporate income tax discourages entry, an effect that will play an important role in the tax reform, and that is analyzed in the next section of the paper.

Quantitative illustration We parameterize the simple model in order to illustrate the discussion on how various forms of taxing capital income affect the life cycle of firms[7]. We simulate in partial equilibrium (e.g. fixed wage rate) the life cycle of a firm in three different scenarios: under the baseline parametrization, and after an increase of 5 percentage points in each of the tax rates, maintaining everything else constant. Figure 1.1 plots the life cycle profile of capital for the four cases considered. Consistent with our discussion above,

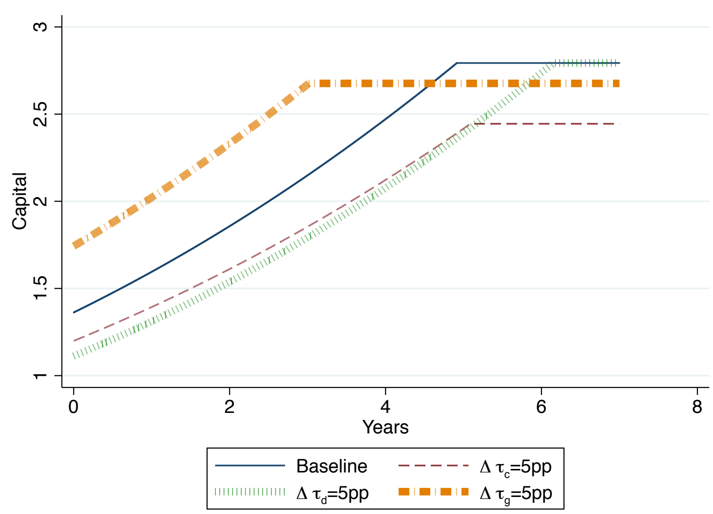
[6] Recall that, in order to minimize taxes on dividends, dividend taxation encourages young firms to finance investment with internal funds.

[7] We set the following parameters for the production function $\alpha = 0.3 \times 0.85, \eta = 0.7 \times 0.85$. The depreciation of capital is fixed as $\delta = 0.05$ and the rate of time preference is set so that the steady state interest rate is 4% ($r = 0.04$). The equity issuance cost is set to 0.10. The wage rate is fixed at 1. Taxes in baseline are $\tau_c = 0.34$, $\tau_d = 0.15$, $\tau_g = 0.15$ and $\tau_r = 0.25$

firms start their life cycle with a lower amount of capital when they are subject to dividend or corporate income taxation. The initial level of capital is slightly lower under dividend taxation than under corporate income taxation. While the level of capital at maturity is not affected by dividend taxation, it is negatively affected by corporate income taxation. This is the key factor explaining why it takes the firm about one more year to reach maturity under dividend taxation, despite the fact that the firm is able to accumulate capital faster under dividend taxation than under corporate income taxation. The latter explains why the age profile of capital in the figure is steeper under dividend taxation than corporate taxation.

It is interesting to compare the effects of dividend taxation with those of capital gains taxation. While dividend taxation does not distort capital accumulation of mature firms, it has a large negative impact on the initial amount of equity at entry. In this way, the firm finances a larger portion of its investment over the life cycle with internal funds, diminishing the present value of taxes paid on dividends. Capital gains taxation does precisely the opposite. It encourages firms to finance a bigger fraction of their investment with external equity, diminishing firm growth over the life cycle, and the present value of taxes paid on capital gains. In terms of capital accumulation, the trade-off is between distorting investments prior to becoming mature (dividend taxation) versus distorting the optimal scale at maturity (capital gains taxation). The corporate income tax distorts investment decisions all through the life cycle.

Figure 1.1: The Life Cycle of a Firm



Life cycle of three identical firms in equilibriums with different taxes. Blue is the baseline: $\tau_c = 0.34$, $\tau_d = 0.15$, $\tau_g = 0.15$ and $\tau_r = 0.25$. Changes after an increase of 5pp of each of the tax rates, maintaining everything else constant.

1.3 The Stochastic Model Economy

The simple model is extended as follows. Following the standard theory of investment, we introduce adjustment costs in capital and uncertainty in productivity. Physical capital evolves according to

$$\dot{k} = x - \delta k.$$

and the resource cost of investing x is given by $x + \Psi \frac{x^2}{2k}$, where the second term reflects the presence of adjustment costs in capital.

The productivity of a firm (z) follows a geometric Brownian Motion

$$dz = \mu z dt + \sigma z dW, \tag{1.23}$$

where μ determines the drift and dW is a Wiener process. Since productivity follows a geometric Brownian motion, large firms in our model follow Gibrat's Law and growth rates are independent of firm size. Empirical research, such as Hall (1987), suggests that Gibrat's Law is a good approximation for firms that are not too small (see also Gabaix (2009)). Similar specification of the productivity shocks has been widely used in the literature on firm dynamics (see Atkeson and Kehoe (2005), Luttmer (2007), Da-Rocha et al. (2017), among many others)[8].

The flow of a firm at time t in state (z, k) with investing expenditures x is given by

$$d - e(1-\xi) = (1-\tau_c)\pi(z,k) - x - \Psi_k \frac{x^2}{2k}, \tag{1.24}$$

where

$$\pi(z,k) = \max_n \{y(z,k,n) - wn\}.$$

[8]Nonetheless, in Appendix D.3 of the paper we consider the robustness of our results to an alternative specification in which productivity follows an autoregressive process.

The firm in state (z, k) solves the following optimal control problem:

$$v(z,k) = \max E_0 \int_0^\infty \left\{ \frac{1-\tau_d}{1-\tau_g} d - e \right\} e^{-(\frac{\rho}{1-\tau_g}+\delta_d)t} dt \tag{1.25}$$

subject to:

$$dz = \mu z dt + \sigma z dW \tag{1.26}$$

$$\dot{k} = x - \delta k \tag{1.27}$$

$$d - e(1-\xi) = (1-\tau_c)\pi(z,k) - x - \Psi_k \frac{x^2}{2k} + \tau_c \delta k, \tag{1.28}$$

where $\frac{\rho}{1-\tau_g} + \delta_d$ is the rate at which the firm discount future payments to/from shareholders when acting in their interest (see Appendix A).

The Hamiltonian-Jacobi-Bellman equation of a firm satisfies:

$$\left(\frac{\rho}{1-\tau_g} + \delta_d\right) v(z,k) = \max \frac{1-\tau_d}{1-\tau_g} d - e + \partial_k v(z,k)\dot{k} + \mu_z z \partial_z v(z,k) + \frac{(z\sigma)^2}{2} \partial_{zz} v(z,k). \tag{1.29}$$

Upon entry, firms draw the initial productivity z_0 from a Pareto distribution:

$$g_e(z_0) = \begin{cases} \epsilon \frac{1}{z_0^{\epsilon+1}} \text{ if } z_0 > 1 \\ 0 \text{ otherwise.} \end{cases} \tag{1.30}$$

The initial amount of equity raised by a firm that draws z solves the following problem:

$$\hat{k}_0(z_0) =_{k_0} \{v(z_0, k_0) - \frac{1}{(1-\xi)} k_0\} \tag{1.31}$$

Then, the value of entry for a firm that draws z can be expressed as

$$v^e(z_0) = v(z_0, \hat{k}_0(z_0)) - \frac{1}{(1-\xi)} \hat{k}_0 \tag{1.32}$$

In equilibrium the free entry condition requires

$$V^e \equiv \int_1^\infty v^e(z_0) g^e(z_0) dz_0 = \int_1^\infty v^e(z_0) \epsilon \frac{1}{z_0^{\epsilon+1}} \leq c_e, \tag{1.33}$$

with strict equality if there is positive entry.

The distribution of firms depends on firms investment and entry decisions. The measure

g of firms in state (z, k) satisfies:

$$0 = -\partial_k \left(s(z,k)g(z,k)\right) - \partial_z \left(\mu_z z g(z,k)\right) + \frac{\sigma_z^2}{2}\partial_{zz} g(z,k) - \delta_d g(z,k) + M g_e(z) I_{k=k_0(z)}, \tag{1.34}$$

where $s(z,k) = \dot{k} = x - \delta k$ and M denotes the mass of firms entering the economy.

In the presence of uncertainty, shocks to firms' productivity may change their financial regimes over the life cycle. A firm that is increasing its capital and issuing equity, may stop doing so if productivity decreases. When productivity decreases by a large amount, the firm may even start distributing dividends and disinvesting. Conversely, an increase in productivity may move the firm back to the equity issuance and investment regime. Appendix C provides a detailed discussion on firms' investment and financial policies in the presence of uncertainty and adjustment costs.

There is a representative household that owns the market portfolio of firms. Households supply labor to firms, receive dividends, buy/sell shares of firms, and trade bonds. Since households do not face uncertainty on their savings, in equilibrium there is a no arbitrage condition (see Appendix A for its derivation) that equates the after-tax return in bonds to the expected after-tax return in each firm. Households pay personal income taxes on earnings (τ_w) and interest income on bonds (τ_r). The government rebates the aggregate tax revenue to the representative household with a lump sum transfer (T).

The representative household maximizes the discounted lifetime utility subject to the intertemporal budget constraint

$$\max_{\{c_t\}} \int_0^\infty e^{-\rho t} u(c_t) dt \tag{1.35}$$

$$\text{subject to:} \tag{1.36}$$

$$\int_0^\infty e^{-r(1-\tau_r)t}(c - (1-\tau_w)w - T) = a_0, \tag{1.37}$$

$$a_0 = \int v(z,k) g(z,k) dz dk, \tag{1.38}$$

where a_0 is the period-0 market value of all firms. In steady state equilibrium, $r_t(1-\tau_r) = \rho$ and $c_t = c\ \forall t$. Note that given that firms cannot borrow, the assumption of a representative consumer implies that bonds are in zero net supply $b_0 = 0$ and households make zero interest income[9].

[9] Appendix D.2 evaluates the sensitivity of the results when an endogenous labor labor supply choice is modeled.

Definition of steady state equilibrium Given a fiscal policy $(\tau_w, \tau_r, \tau_c, \tau_g, T)$, a steady state equilibrium is given by value functions for incumbent firms $(v(z,k))$, value of entry V^e, prices (w,r), firms policy functions on employment (n), investment in physical (x) and financial policies (d,e) , initial equity k_0, mass of entry M, measure of firms $g(z,k)$, consumption c and initial household assets a_0 such that:

1. Given prices, the value function $v(z,k)$ satisfies the HJB equation of the firm and firm decisions (n,x,d,e) are optimal.

2. V^e satisfies the free entry condition (1.33).

3. The government budget constraint is satisfied (all tax revenue is rebated back to consumers as a lump sum transfer).

4. Households maximize utility taking as given government transfer, prices, and initial wealth, which implies that steady state consumption is equal to permanent income: $c = \rho a_0 + w + T$.

5. Labor, bonds, and goods market clear

$$\int n(z,k)g(z,k)dzdk = 1$$

$$c + c_e M + \int \left[x + \psi \frac{x^2}{k}\right] g(z,k)dzdk = \int z^{1-\alpha-\gamma} k^\alpha n^\gamma g(z,k)dzdk. \tag{1.39}$$

1.3.1 Quantitative Analysis

Calibration

The calibration targets aggregate and firm level data from the US economy. In principle, our goal is to target all US businesses that pay corporate income taxes. The calibration requires targeting "dynamic moments" from US firms, such as average firm growth, volatility and autocorrelation of investment rates over time. We follow Gourio and Miao (2010) in using Compustat data to pin down these calibration targets. Hence, the calibration strategy implicitly assumes that privately held businesses and publicly traded companies are alike with regards to employment growth, investment rates, and equity issuance by privately held businesses. The key difficulty is that there is very limited longitudinal data on private corporations. However, Haltiwanger (2006) provides evidence that both private and public firms face a life cycle in which net employment growth tends to be higher for young firms than mature firms even when controlling for firm size. Moreover, Asker et al. (2011) analyze a new data set on private US firms and find that firm growth, investment, return on assets are similar across private firms in this database and public firms in Compustat. To the extent that private corporations face a higher cost of external financing, the former type of firms should gain more than the latter from reducing corporate income taxes.

We also target cross-sectional data on the size distribution of businesses from the US Census Bureau. Now, the universe of US businesses include private pass-through businesses that are not subject to the US corporate income tax (S corporations, partnerships).[10] Since most of these businesses tend to be small, as a compromise we target data on the size distribution of businesses that includes businesses with more than 50 employees. The set of parameters to be calibrated is divided in two groups.

Parameters assigned without solving the model. The tax parameters are from the Internal Revenue Service (year 2015). The corporate income tax rate is 34% ($\tau_c = 0.34$)[11]. The capital gains tax rate is set to 0.15 ($\tau_g = 0.15$), the dividend tax rate to 0.15 ($\tau_d = 0.15$), and the personal income tax rate to 0.25 ($\tau_r = 0.25$, $\tau_w = 0.25$[12]), which corresponds to the marginal Federal taxes faced by a married couple with the average household income in the US. Households are assumed to discount future utility at an annual rate of 0.0375 ($\rho = 0.0375$) so that the (before tax) steady state return on capital is 5%, consistent with the estimates of the return on capital by Cooley and Prescott (1995). The parameters on the production function are set to standard values in the literature: the profit share is set to 0.15, with 70% of the remaining share going to labor and 30% to capital ($\alpha = 0.85 * 0.3, \eta = 0.85 * 0.7$), as in Midrigan and Xu (2014). The depreciation rate of capital is set at 0.05 per year ($\delta_k = 0.05$). Based on data from US Census Bureau's Business Dynamic Statistics (BDS), the average annual exit rate of firms with more than 50 employees is 4.6%, so $\delta_d = 0.046$. Using data from Thomson Reuter's Securities Data Company (SDC) Platinum, we find that during the period 1995-2015 the total costs of equity issuance as a percentage of proceeds is about 7%[13]. This is computed following closely the procedure of Lee et al. (1996) for IPO firms. It is somewhat smaller than the ones reported by Hennessy and Whited (2007), who estimated equity issuance cost in the range of 8.3% to 10.1%. Hence, the cost of raising external funds is set to 0.07 ($\xi = 0.07$). Nonetheless, firms raising their initial capital at entry face a higher equity issuance cost ξ_e. This parameter will be determined later by simulating the model economy. Our calibration requires that $\xi_e > 0.07$

[10] Developing a theory of organizational choice (pass through entities versus C corporations) is outside the scope of the current paper. See Dyrda et al. (2018) for a theory of organizational choice.

[11] The progressive rate structure of the federal corporate tax in the US is designed such that it produces a flat 34% tax rate on incomes from $335,000 to $10,000,000, gradually increasing to a flat rate of 35% on incomes above.

[12] Labor income tax rate is kept constant in all experiments.

[13] See Appendix B.2 for more details on the data and computation.

in order to match the equity issuance by incumbent firms.

Parameters assigned by solving the model. It remains to assign the parameters driving the stochastic process on productivity (μ_z, σ_z), the parameter Ψ driving adjustment costs, the productivity distribution of firms that enter the economy and their cost of raising external capital. Entering firms draw their initial productivity from a Pareto distribution with tail parameter η_p and a location parameter 1 (the lowest possible productivity is one). The wage rate is normalized to 1, and the fixed cost of entry is set equal to the value of entry.

Targeted moments. Although the endogenous equilibrium outcomes of interest will be jointly determined by all of these parameters, each of these parameters is intuitively connected with a particular moment of interest. The parameter μ_z is closely connected with firm growth and σ_z with the variance of investment. The parameter Ψ is closely related to the correlation of investment rates across two consecutive years and the parameter determining the Pareto tail with the size distribution of businesses. Finally, the cost of raising initial equity is closely connected to the amount of external finance by incumbent firms. With these connections in mind, the following statistics are targeted:

1. An average annual employment growth of 2.1%.

2. The volatility of the investment rate (x/k) among firms of 0.059.

3. The autocorrelation of investment rates between two consecutive years of 0.57.

4. The ratio of equity issuance by incumbent firms to investment of 12.6%.

5. The size distribution of businesses, computed using data from BDS and reported in Table 1.2.

The first 4 targets are computed using Compustat data from over the period 1995-2015.[14] For the reasons previously discussed, in computing the size distribution of businesses we abstracted from small businesses in the BDS and focused on businesses with more that 50 employees. Tables 1.1 and 1.2 show the parameter values and the calibration results.

Parameter values and discussion. The model accounts well for the targeted moments. The baseline economy matches the average employment growth of 2.1 percent in the data. Recall that productivity in our model economy follows a geometric Brownian Motion with a drift given by $\mu = \mu_z + \frac{\sigma_z^2}{2}$[15]. Hence, the variance of shocks is a force driving firm

[14] See Appendix B.1 for more information about the data and variable construction.

[15] This follows from Ito's lemma, and the specification of the process of productivity growth in our model, i.e. $dlnz = \mu_z dt + \sigma_z dW$

Table 1.1: Calibration Baseline Economy

Parameter	Description	Value
ψ	Capital adjustment cost	0.09
μ	Productivity drift	-0.00325
σ	Volatility of prod. shock	0.15
ξ_e	Financing cost at entry	0.30
η_p	Distribution of businesses	1

growth.[16] The model economy accounts for the 2.1% in average employment growth with $\mu_z = -0.00325$. To measure the volatility of the investment rate and its autocorrelation over time in our baseline economy, we first solve the model to compute the stationary distribution of firms. Then, we draw firms from this distribution and simulate them over the year to compute annual investment rates. The annual volatility of the investment rate in the baseline economy is 0.054, which is close to the value of 0.059 in the data. Matching this target requires a significant variance in productivity since $\sigma_z = 0.15$[17]. The parameter $\psi = 0.07$ is set to match the autocorrelation of annual investment rates over two years across the stationary distribution of firms. This parameter is between the 0.049 estimated by Cooper and Haltiwanger (2006) and the 1.08 value obtained by Gourio and Miao (2010). The size distribution of businesses in the baseline economy is determined by the distribution of businesses at entry and by the stochastic growth in productivity over the life cycle of firms. The model accounts reasonably well for the size distribution of businesses, although the match is not perfect. The model implies that 50 percent of businesses have fewer than 100 workers, and 22 percent of businesses employed between 100 workers and 250 workers. The corresponding fractions in the data are 53% and 29%. The fraction of businesses with more than 5,000 employees are about 0.6% in the model economy and 1% in the data[18].

A crucial parameter in our model economy is given by the cost of external financing. As in Korinek and Stiglitz (2009), financial frictions matter for the different financial regimes that firms go through their life cycle[19]. In particular, we want our model economy to be

[16] Moreover, the distribution of productivity at entry is such that most businesses in our baseline economy start their life with a low productivity level, not far from the minimum value of 1, which represents a low barrier on z.

[17] Nonetheless, recall that z in the production function is raised to the power of 0.15 so that the variance of TFP is much smaller than the one in z. For instance, Gourio and Miao (2010) estimate a variance in TFP of 0.2, though in their model TFP follows an autoregressive process with persistence of about 0.8

[18] In the data, most large firms are multi-establishment, a fact that our model cannot account for. This is the main reason our model underpredicts mass in largest size category.

[19] Gourio and Miao (2010)'s model abstracts from financial frictions and life cycle. Firms in their model go through different financial regimes because of the differential tax treatment on dividends and capital gains during the year 2003.

consistent with data on firm growth, investment rates, and the fraction of investment financed by raising capital on the equity market. Recall that the cost of external finance was set exogenously at 7 percent using data from SDC Platinum. The model economy matches the 13 percent target for the fraction of investment financed by equity issuance among incumbent firms. To match this statistic, the model requires that firms at entry face substantial financial frictions. The baseline economy assumes that when firms enter the economy they face equity issuance costs of 0.30. Lower values of equity issuance costs at entry imply that firms raise a substantial amount of equity when they enter in order to invest a large amount and avoid adjustment costs in capital as they grow (in expectations) over their life cycle. While we do not have data on the cost of raising external funds when firms are created, we find that the cost of raising external funds in initial public offerings in the SDC data is about 12%. Presumably, the cost of raising external funds when businesses are actually created should be much larger. Moreover, our model assumes that firms learn their productivity before making the initial investment in capital. Firms in our model would invest less when they enter if they face some uncertainty on their initial productivity and learn it over time. Hence, our calibrated equity issuance cost at entry may be capturing the effects of information frictions that our model abstracts from.

Table 1.2: Calibration Results

	Data	Model
Target		
Avg. employment growth	0.02	0.02
Volatility investment rate	0.059	0.054
Autocorrelation invest. rate	0.57	0.59
Eq. issuance incumbents/investment	0.13	0.13
Size Distribution of Businesses		
No. of Employees	Fraction Data	Fraction Model
$[50, 99)$	0.53	0.50
$[100, 249)$	0.29	0.22
$[250, 499)$	0.089	0.13
$[500, 999)$	0.0429	0.07
$[1000, 2499)$	0.0265	0.047
$[2500, 4999)$	0.0099	0.018
$[5000, \infty)$	0.0115	0.0057

Targeted moments in the data, and their respective counterpart in the model. Data comes from Compustat, and BDS for the size distribution of businesses.

Other non-targeted moments. The aggregate investment rate (x/k) in the model economy is 0.096, somewhat above the 0.086 value from the National Income Accounts. The model economy overstates the ratio of aggregate dividends to aggregate earnings in Compustat (0.45 versus 0.098). This also happens in the model by Gourio and Miao (2010). Perhaps this should not be surprising since both model economies abstract from share repurchases, which is another way of dividend distribution. The model does a decent job in matching the ratio of aggregate equity issuance to aggregate investment in the data (0.15 versus 0.19). Moreover, the share of equity issuance by entrants relative to aggregate investment is 0.037 in the data and 0.067 in the model.[20]

Table 1.3: Non-targeted Moments

Variable	Data	Model
Investment rate	0.086	0.096
Dividends/Earnings	0.098	0.45
Agg. eq. issuance/ agg. investment	0.15	0.19
Eq issuance entrants/agg. investment	0.037	0.067

Non-targeted moments in the data, and their respective counterpart in the model. Data moments from Compustat.

In Figure 1.2, we plot age profiles of employment growth by firms[21] in the model and the data. Although it is an untargeted moment, the model captures quite well the sharp decline in employment growth as firms age. In our model economy young firms are small and constrained, so they grow fast at the beginning. As they age and accumulate internal funds, they are likely to become less constrained and progressively reach their optimal size. As a result, the age-profile of employment growth of firms is expected to decrease with age. The fact that the baseline economy matches reasonably well the decline in the growth rate of employment with age suggests that the model is not exaggerating the impact of financial frictions on firm growth.

1.3.2 Aggregate effects of reforming the taxation of capital income

We now consider the long run effects of a tax reform that eliminates the taxation of corporate income while keeping constant the tax revenue. This is done by finding the common tax rate (τ) on all forms of capital income (dividends τ_d, interest income τ_r, and capital gains τ_g) that

[20]To measure the share of equity issuance by new entrants and by incumbents in Compustat, we add up the equity issuance of all firms that report doing an IPO in that same year on one side, and the rest of the firms operating in that year on the other, and divide both by the sum of investment in capital expenditures of all firms.

[21]Unfortunately, age is not a variable available in Compustat, so we construct a proxy with the available data, and define age as years since their IPO.

Figure 1.2: Employment growth by age in the model and the data.

Average employment growth by age. Blue line is data generated from the model, orange line is data from Compustat, where age is computed in the as years since IPO (see Appendix B.1).

collects the same tax revenue as in the baseline economy[22]. The purpose of the proposed policy reform is twofold. Firstly, by equating the three tax rates, all forms of capital income are treated symmetrically from the household perspective. Secondly, by eliminating the corporate tax, financially constrained firms can accumulate profits and reach maturity (the dividend distribution stage) faster (in expectations).

We emphasize that the key insights from our simple model apply to the current stochastic model. Financial frictions imply that firms start their life constrained. For fixed productivity, firms build internal equity over time, becoming less constrained and eventually start distributing dividends. Stochastic shocks imply that firms distributing dividends might become liquidity constrained again if their productivity grows sufficiently over time, so that the "life cycle process" is initiated again. By reducing the corporate tax and increasing the dividend tax, our proposed tax reforms intend to shift the tax burden from liquidity constrained firms (with high marginal valuation of capital) to firms distributing dividends (with low marginal valuation of capital). However, the effects of the reform are more involved than it seems at first sight. This is because firms react to higher dividend taxes by diminishing initial equity, raising the likelihood that firms become liquidity constrained, and

[22] The tax rate on wages τ_w is kept fixed in all the experiments

(partly) reversing the gains pursued with the elimination of corporate income taxation (see Section 1.2.4)[23]. To minimize these effects, our proposed tax reform involves raising capital gains taxes *together* with dividend taxes. The rise in capital gains taxes encourages firms to issue more equity in order to minimize taxes paid on capital gains, (partly) undoing the distortions of dividend taxation on initial equity decisions (see discussion in Section 1.2.4).

To check for potential non-linearities in the responses to tax changes, a tax reform that reduces the tax rate on corporate income to 0.21 is also considered. This experiment is also of interest since in 2017, the US corporate income tax rate was reduced to 0.21. To isolate the role of capital gains taxation from dividend taxation, we consider a tax reform that sets the corporate income tax rate to 0.21 while keeping the other tax rates at their value in the baseline economy. In this experiment, the dividend tax rate is raised to keep the government budget balanced. Finally, we consider a fourth tax reform in which the investment at entry is subsidized at the rate at which dividends are taxed. In order to evaluate the importance of entry for understanding tax responses, we also perform all the tax reforms in an economy in which entry is kept fixed at its value in the baseline economy[24].

As further sensitivity analysis, Appendix D.1 considers economies in which the cost of entry rises proportionally (or more than proportionally) to the wage rate[25]. Appendix D.2 studies the sensitivity of the results when the representative household is allowed to choose labor hours (rather than being fixed as in the baseline economy).

Tax reform 1: Elimination of corporate income taxes

The results are shown on Table 1.4. The elimination of the corporate income taxes in the baseline economy ($\tau_c = 0.34$) should be accompanied by an increase in capital income taxes to 0.41 to keep government revenue constant (recall that in the baseline economy the dividend and capital gains tax was set to 0.15 and the interest income tax was set to 0.25). This revenue neutral tax reform leads to an increase in aggregate output of 12.2%, which is accompanied by a large increase in the aggregate capital stock (31.8%), in the number of firms (34.5%), and in aggregate TFP (4.6%). Note that the fact that aggregate capital and output rise less than the number of firms, indicates that both capital per firm and output per firm decrease (by 2% and 17%, respectively). Hence, the response of firm entry to the tax reform is crucial for the large increase in aggregate output and aggregate TFP in the

[23] By financing a larger fraction of investments with internal funds, they reduce the cost of capital.

[24] This is done by fixing the mass of firms to that of the baseline, and finding wages from the labor market clearing condition.

[25] The cost of entry depends on the wage rate: $c_e = \bar{c}_e w^{\phi}$, where the parameter ϕ determines the elasticity of entry costs to wage changes. The baseline economy implicitly assumes $\phi = 0$. Appendix D.1 considers alternative economies with $\phi = 1$ and $\phi = 2$.

Table 1.4: Effects of Tax Reforms

	Y	K	TFP	M_e	Wage	Value entr.	Value incu.	k_0	k	τ
Tax Reform 1: $\tau_c = 0$; financed by raising $\tau_d = \tau_g = \tau_r$										
Baseline	12.2	31.8	4.6	34.5	12.2	1.2	-0.8	5.5	-2.1	0.41
No entry	3.7	15.4	0.0	0.0	3.7	16.3	15.6	19.3	15.4	0.48
Tax Reform 2: $\tau_c = 0.21$; financed by raising $\tau_d = \tau_g = \tau_r$										
Baseline	6.0	14.8	2.3	16.4	6.0	0.3	-0.7	1.3	-1.4	0.26
No entry	1.9	7.5	0.0	0.0	1.9	7.5	7.7	6.3	7.5	0.31
Tax Reform 3: $\tau_c = 0.21$; financed by raising τ_d										
Baseline	-1.2	10.0	-3.6	-19.1	-1.2	-1.9	5.0	-9.1	36.0	0.39
No entry	3.4	15.7	-0.4	0.0	3.4	-5.3	-2.1	-8.9	15.7	0.32
Tax Reform 4: $\tau_c = 0.21$, financed by τ_d, including a subsidy to entry τ										
Baseline	6.3	20.4	1.4	9.7	6.3	18.0	-6.1	137.3	9.8	0.29
No Entry	4.1	17.6	-0.2	0.0	4.1	20.0	-3.6	141.2	17.6	0.32

Percent changes from the baseline. From left to right: aggregate production (Y), aggregate capital (K), aggregate TFP (TFP), mass of entrants (M_e), average value of entrants gross of initial equity payment (Value entr.), average value of incumbents (Value incu.), average capital at entry (k_0) and average capital (k). In each experiment, we decrease corporate tax, but change other taxes τ such that the government revenue is constant. τ corresponds to the value of the tax rate being changed, specified in each line.

baseline economy. When entry is kept fixed at the value in the baseline economy, aggregate output increases by 3.7% and capital by 15.4%. Hence, the increase in output is about a third the one in the baseline economy and the increase in capital is about half. Note that output per firm and capital per firm rise since the number of firms is kept constant[26].

Crucially for our results, in our baseline economy the tax reform increases the expected value of entry more than the value of incumbent firms, which leads to a reallocation of resources from mature to young firms, and hence to an increase in entry and in the equilibrium wage rate. Note that corporate income taxation has asymmetric effects across firms depending on their financial regime. The elimination of corporate income taxation allows financially constrained firms to retain a larger fraction of their earnings and increase their investments. The ability to retain earnings is particularly relevant for young firms, which are more likely to be constrained than the average incumbent firm in the economy. The value of entry is determined by the average value of age-0 firms. This observation explains why, keeping the wage of the baseline economy fixed, the value of the average firm entering the economy increases more than that of incumbent firms (60% versus 54%) with the elimination of corporate income taxes. In general equilibrium, the increase in the value of entry requires the wage rate to rise by about 12.2% in order to restore the free entry condition. The rise in the wage rate reduces the value of incumbent firms (by 0.8%) and aggregate labor demand. Hence, firm entry rises (by 34.5%) in order to clear the labor market. When the number of firms is kept fixed, the wage rate rises by a more modest amount (3.7% instead of 12.2%) for the labor market to clear. The average firm is 15.4% larger.

Summing up, we find that in general equilibrium the elimination of corporate income tax shifts resources from old to young businesses, decreasing the market value of incumbent firms relative to entrants. The equilibrium wage rate and business entry rise. The response of entry is crucial for the large increase in aggregate output and TFP.

Tax reform 2: $\tau_c = 0.21$ and increase all other capital income taxes

The corporate income tax rate is set as $\tau_c = 0.21$ while all other capital income taxes are set to 0.26 ($\tau_g = \tau_d = \tau_r = 0.26$). The reduction in the corporate tax rate is about 40% of the one in the previous experiment (0.13 percentage point decrease instead of 0.34). We find that output increases by 6.0% and entry increases by 16% (see Table 1.4). These magnitues are about half the ones obtained when the corporate income taxation was eliminated (12.2% increase in output and 34.5% increase in entry). Hence, the effects on output and entry of reducing the taxation of corporate income are non-linear but not too far from linearity.

[26] Given the importance of entry for our results, Appendix D.1 reports the effects of tax reforms in two new model economies that vary in the response of entry to tax changes.

Tax reform 3: $\tau_c = 0.21$ and only increase dividend tax

The corporate income tax rate is set as $\tau_c = 0.21$ and the dividend tax rate is set to $\tau_d = 0.39$ to balance the governnment budget constraint. The tax rates on capital gains and on interest income are kept fixed at their values in the baseline economy. The results in Table 1.4 show that output decreases by 1.2%. Recall that the previous reform (which sets the corporate income tax to 0.21 while equating the tax rates on dividends and capital gains) lead to an output gain of 6%. Hence, the output gains of equating the tax rates on capital gains and dividends are substantial. Why is this the case? When τ_g is substantially below τ_d, firms have strong incentives to accumulate capital internally (see the discussion in Section 1.2.4). As a result, firms enter the economy with a small size. The average initial equity is reduced by 9% relative to the baseline economy (while in Tax Reform 2 it is slightly higher than in the baseline economy). Firms take more time to grow which reduces the value of entrants. As a result, relative to the baseline economy, entry is reduced by 19%. The fact that aggregate capital rises by 10% while the number of firm decreases implies that the average firm is much bigger than in the baseline economy (36% in terms of capital and 24% in terms of labor). When the dividend tax is higher than the capital gains tax, the tax code makes equity financing more costly than financing with retained earnings, thereby hurting young firms and entry, favoring investment by incumbent firms and leading to an increase in the average business size. In the next tax reform, we show that these effects can be (partially) reversed if the high dividend tax (relative to the capital gains tax) is compensated with a subsidy to initial equity issuance.

Tax reform 4: $\tau_c = 0.21$, increase dividend tax and introduce a subsidy to entry

The results from the last experiment point to the importance of equating the tax rate on capital gains and dividends. If the wedge between the dividend tax rate and the capital gains tax rate is large, firms invest too little when they enter and financial frictions have more negative effects on firm growth. One concern is that capital gains in the US are taxed upon realization, while in the model economy they are taxed on an accrual basis. Since the realization of capital gains is an endogenous decision, the model economy might be overstating the effects of capital gains taxation. Therefore, we consider the following variation of the previous tax reform: the reduction of the corporate income tax rate to 0.21 is accompanied by a subsidy to initial equity issuance. The dividend tax rate is set to balance the government budget constraint, and the subsidy to initial equity is set to τ_d. Hence, equation (1.31) now reads:

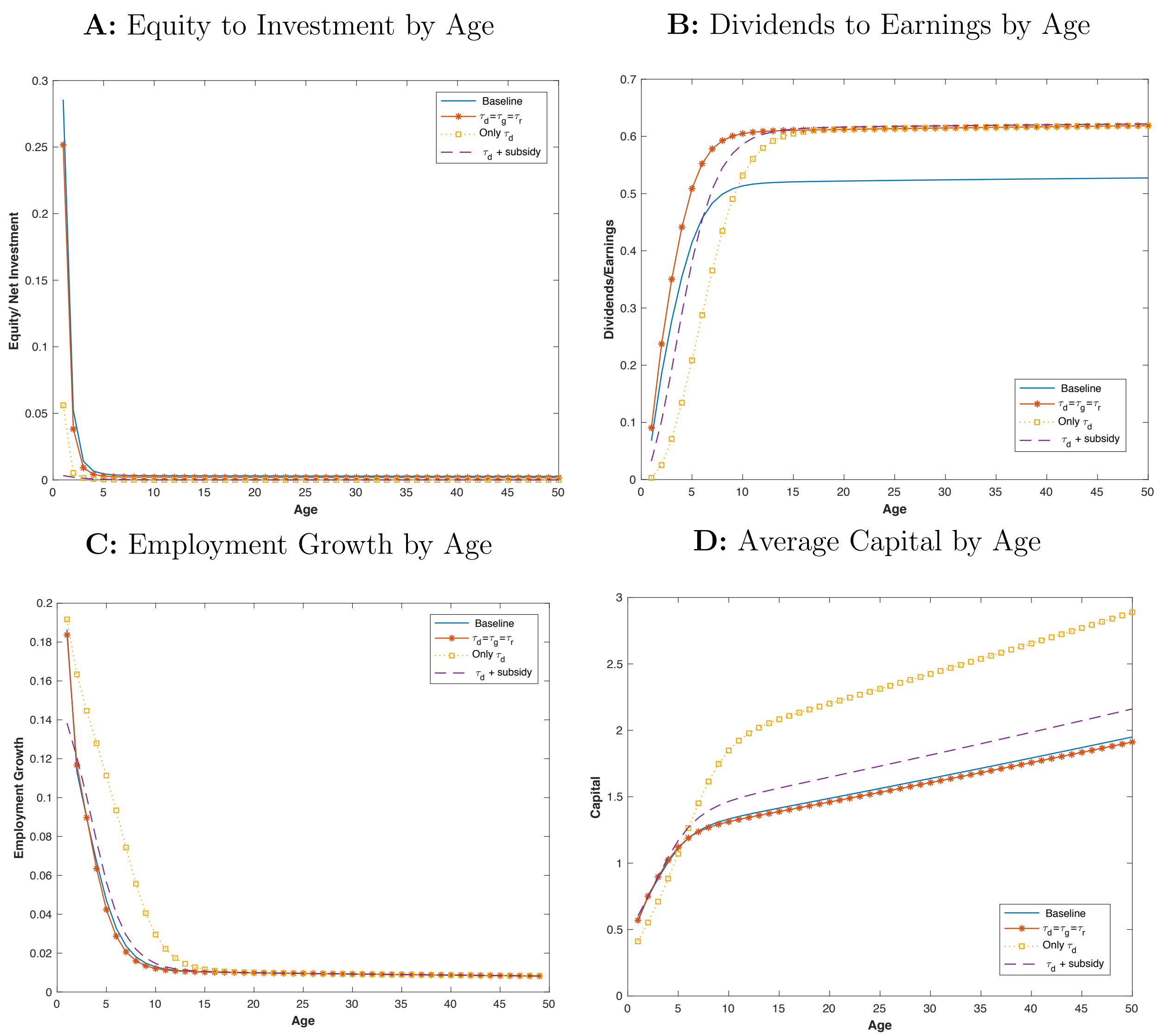
$$\hat{k}_0(z_0) =_{k_0} \{v(z_0, k_0) - \left(\frac{1}{(1-\xi)} - \tau_d\right) k_0\}. \tag{1.40}$$

The purpose of this tax reform is to treat symmetrically investment financed with retained earnings or with equity issuance. In the presence of a dividend tax, the government is effectively sharing a fraction τ_d of the investment costs of mature firms. Then, by subsidizing initial equity issuance at a rate τ_d the government is treating symmetrically investment by new firms and incumbent (mature) firms. This reform leads to an increase in output of 6.3%, which is similar to the one obtained under Tax Reform 2. The key difference between these reforms is that the average firm size increases by 9.8% under tax reform 4 and decreases by 1.4% under tax reform 2. The higher average firm size under tax reform 4 is due to a larger firm size both at entry and at maturity (see (1.19)). Entry is less responsive under tax reform 4 than tax reform 2, despite the fact that the former reform directly subsidizes entry. This paradoxical observation is explained by the fact that the equilibrium mass of entry is determined to clear the labor market. Since the average firm is larger under tax reform 4 than tax reform 2, entry is lower in the former case.

Taxation and the life cycle of firms

It is interesting to compare the average life cycle behavior of firms across the model economies. Panel A of Figure 1.3 shows the average equity to investment ratio for the baseline economy and the economies with the Tax Reforms 2, 3 and 4. When the capital gains tax is smaller than the dividend tax (Tax Reform 3), firms are much more reluctant to finance investment with equity issuance. Moreover, as shown in Panel B of the same figure, firms distribute much fewer dividends when young in Tax Reform 3 because they are (slowly) building internal equity. In Tax Reform 4, firms do not issue much equity, since they start while already big, but the time it takes them to reach maturity is longer than under Tax Reform 2, because their optimal size is larger. Nonetheless, when firms mature there are no differences in the dividends to earnings ratio under the Tax Reforms 2, 3 and 4. Mature firms in the baseline economy distribute a lower fraction of their earnings because they are paying higher corporate taxes than in the other two economies. Panel C of Figure 1.3 shows that the mean employment growth rate of firms is much higher under Tax Reform 3. Again, when capital gains taxes are lower than dividend taxes, firms start small and grow fast by retarding dividend payments and accumulating internal equity. Since firms discount future payouts at a low rate when capital gains taxes are low, they have a strong incentive to grow over their life cycle. Even though the average firm size at entry is smallest under Tax Reform 3, the average size late in the life cycle is the largest across all economies (see Panel D). The large dispersion in business size over the life cycle and the low entry under Tax Reform 3 explains why this economy features the lowest TFP among all the economies considered. Note that in Tax Reform 4, average size is larger than in Tax Reform 2 since capital gains taxes, which distort optimal size, are maintained at the baseline level while decreasing coporate taxes.

Figure 1.3: Life Cycle of Firms



Average age profiles for equity to investment, dividends to earnings, employment growth and capital. Blue solid line (Baseline) corresponds to the baseline calibration. Starred orange line ($\tau_d = \tau_g = \tau_r$) corresponds to Tax Reform 2, i.e. $\tau_c = 0.21$, and $\tau_d = \tau_g = \tau_r = 0.26$ to keep the governement budget constraint balanced. Dotted yellow line (Only τ_d) corresponds to Tax Reform 3, i.e. $\tau_c = 0.21$, and $\tau_d = 0.39$ to keep the governement budget constraint balanced, while the other taxes are set to their baseline values ($\tau_g = 0.15$, $\tau_r = 0.25$). Dashed purple line (τ_d + subsidy) corresponds to Tax Reform 4, i.e. $\tau_c = 0.21$, $\tau_d = 0.29$ and a subsidy to entry equal to τ_d financed by the government, maintaining the governement budget constraint balanced, while the other taxes are set to their baseline values ($\tau_g = 0.15$, $\tau_r = 0.25$).

1.4 Conclusions

In this paper, we use a model of firm dynamics with endogenous entry to analyze the impact of different forms of taxing capital income on investment over the life cycle of firms and on firm entry. We use the calibrated model economy to quantitatively assess the effects of a reform that eliminates the taxation of corporate income while keeping constant the tax revenue collected on capital. This is done by finding the common tax rate (τ) on all forms of capital income (dividends τ_d, interest income τ_r, and capital gains τ_g) that collects the same tax revenue as in the baseline economy. The purpose of the proposed policy reform is twofold. Firstly, by equating the three tax rates, we would be treating symmetrically all forms of capital income from the household perspective. Secondly, by eliminating the corporate tax, financially constrained firms can accumulate profits and reach maturity (the dividend distribution stage) faster. This revenue neutral tax reform leads to an increase in aggregate output of 12.2%, which is accompanied by a large increase in the aggregate capital stock (31.8%) and in the number of firms (34.5%). Note that the fact that aggregate capital and output rise less than the number of firms indicates that the average size of the firm is smaller after the tax reform. Hence, it is the large response of firm entry to the tax reform that drives the large increase in aggregate output and capital.

At the heart of our results is the fact that the tax reform increases the expected value of entry more than the value of incumbent firms, leading to a reallocation of resources from mature to younger firms that operates through an increase in entry and in the equilibrium wage rate. The elimination of corporate income taxation allows financially constrained firms to retain a larger fraction of their earnings and increase their investments. The ability to retain earnings is particularly relevant for young firms, which are more likely to be constrained than the average incumbent firm in the economy. Since the value of entry is determined by the average value of age-0 firms, the value of the average firm entering the economy increases more than that of incumbent firms when corporate income taxation is eliminated. In general equilibrium, the increase in the value of entry requires the wage rate to rise, which reduces labor demand by incumbent firms. Labor market clearing requires a larger mass of firm entry. Larger firm entry together with a reallocation of resources to financially constrained firms lead to an increase in aggregate TFP of 4.6%.

Our paper abstracts from many effects of corporate income taxation. In particular, the corporate income is likely to affect the organizational form of firms, the incentives of firms to borrow and to invest in intangible capital. While these issues are out of the scope of the current paper, they are important for having a complete assessment of the impact of corporate income taxation.

1.5 Appendix

Appendix A Asset Pricing

We derive some useful results on asset prices by considering a discrete time version of the model with $\delta_d = 0$[27]. Consider a small time interval Δ. In equilibrium the following no arbitrage condition must hold:

$$\Delta R_t = \frac{1}{P_t} E_t \left[(1-\tau_d) d_{t+\Delta} \Delta + (1-\tau_g)(P_{t+\Delta} - e_{t+\Delta}\Delta - P_t) \right], \tag{1.41}$$

where $R = r(1-\tau_r)$ denote the returns on bonds.

Dividing by Δ in both sides yields:

$$R_t = \frac{1}{P_t} E_t \left[(1-\tau_d) d_{t+\Delta} - (1-\tau_g) e_{t+\Delta} + (1-\tau_g) \frac{P_{t+\Delta} - P_t}{\Delta} \right] \tag{1.42}$$

Taking the limit as $\Delta \to 0$, yielding to the non-arbitrage equation in the main text.

To obtain the HJB equation satisfied by the firm value function, use (1.41) to solve for P_t:

$$P_t = \frac{E_t \left\{ \left[\frac{1-\tau_d}{1-\tau_g} d_{t+\Delta} - e_{t+\Delta} \right] \Delta + P_{t+\Delta} \right\}}{1 + \frac{\Delta R_t}{1-\tau_g}} \tag{1.43}$$

Define the cum-dividend value of equity net of taxation on dividends and capital gains as: (for every t):

$$V_t = \left[\frac{1-\tau_d}{1-\tau_g} d_t - e_t \right] \Delta + P_t \tag{1.44}$$

Combining (1.44) and (1.43) yields:

$$V_t = \left[\frac{1-\tau_d}{1-\tau_g} d_t - e_t \right] \Delta + E_t \left(\frac{V_{t+\Delta}}{1 + \frac{\Delta R_t}{1-\tau_g}} \right). \tag{1.45}$$

The date-0 value of the firm is obtained as follows:

$$V_0 = E_0 \sum_{t=0}^{\infty} \left[\frac{1-\tau_d}{1-\tau_g} d_t - e_t \right] \Delta \frac{1}{\Pi_{j=0}^{t} \left(1 + \frac{\Delta R_j}{1-\tau_g} \right)}, \tag{1.46}$$

[27] The analysis in Appendix A builds on Gourio and Miao (2010).

which taking the limit $\Delta \to 0$ yields:

$$V_0 = E_0 \int_0^\infty \left[\frac{1-\tau_d}{1-\tau_g} d_t - e_t\right] e^{-\frac{\int_0^t R_s ds}{1-\tau_g}}, \tag{1.47}$$

which gives the objective function in the problem of the firm stated in the text.[28]

To derive the HJB equation of the stochastic model economy derived in Section 3 of the paper, re-arrange equation 1.45 to get

$$R_t \Delta V_t = [(1-\tau_d)d_t - (1-\tau_g)e_t]\,\Delta\left(1 + \frac{R_t\Delta}{1-\tau_g}\right) + (1-\tau_g)E_t(V_{t+\Delta} - V_t) \tag{1.48}$$

Dividing by Δ and taking the limit $\Delta \to 0$ gives

$$R_t V_t = (1-\tau_d)d_t - (1-\tau_g)e_t + (1-\tau_g)E_t(dV_t) \tag{1.49}$$

Applying Ito's Lema, $E(dV) = \frac{\partial V}{\partial t} + \frac{\partial V}{\partial k}\dot{k} + \frac{\partial V}{\partial z}\mu z + \frac{1}{2}\frac{\partial^2 V}{\partial z^2}(\sigma_z z)^2$

Hence,

$$R_t V_t = (1-\tau_d)d_t - (1-\tau_g)e_t + (1-\tau_g)\left\{\frac{\partial V}{\partial t} + \frac{\partial V}{\partial k}\dot{k} + \frac{\partial V}{\partial z}\mu z + \frac{1}{2}\frac{\partial^2 V}{\partial z^2}(\sigma_z z)^2\right\} \tag{1.50}$$

Dividing both sides of the above equation by $1-\tau_g$ yields:

$$\frac{R_t}{1-\tau_g}V_t = \frac{1-\tau_d}{1-\tau_g}d_t - e_t + \frac{\partial V}{\partial t} + \frac{\partial V}{\partial k}\dot{k} + \frac{\partial V}{\partial z}\mu z + \frac{1}{2}\frac{\partial^2 V}{\partial z^2}(\sigma_z z)^2, \tag{1.51}$$

which coincides with the HJB equation in the paper.

Appendix B Data Variables

Appendix B.1. COMPUSTAT North America

We use data from COMPUSTAT North America obtained via WRDS. We use an unbalanced panel of firms from 1995-2015. We exclude firms whose industry classification is in utilities (SIC codes between 4900 and 4949) or the financial sector (SIC code between 6000 and 6999), following the literature[29]. We also exclude observations reporting a value of acquisitions to

[28] The discount rate in the paper is denoted by $m = \frac{R}{1-\tau_g} = \frac{r(1-\tau_r}{1-\tau_g}$. When exogenous death of the firm is allowed, firms discount future payout at a rate $m + \delta_d$, where δ_d is the death rate. The value of the firm in the deterministic problem is just a special case of the stochastic case.

[29] These companies are usually excluded since they face additional regulations and hence might have different payout behavior, and their dividend patterns are quite different from other companies.

assets larget than 5%, since these firms might behave differently. We finally exclude firms reporting negative employment, sales, wages or investment. All dollar values are in million dollars (1999 real terms, deflated using the GDP deflator from the U.S. Bureau of Economic Analysis[30]), and all firm-level measures are winsorized at the 1st and 99th percentile. The raw variables we are going to use are the following:

- **Dividends.** Total amount of dividends, other than stock dividends, declared on all equity capital of the company, based on the current year's net income (DVT item). We restrict the analysis to those reporting DVT greater or equal to 0.
- **Equity Issuance.** Funds received from issuance of common and preferred stock (SSTK item). We restrict the analysis to those reporting SSTK greater or equal to 0.
- **Capital.** It represents the cost, less accumulated depreciation, of tangible fixed property used in the production of revenue, which is a component of total assets (PPENT item).
- **Age.** Computed as current year minus year of their IPO (IPODATE item)[31].
- **Employees.** Number of company workers as reported to shareholders. This is reported by some firms as an average number of employees and by some as the number of employees at year-end (EMP item).
- **Earnings.** Measured as Operating Income Before Depreciation (OIBDP item).

Table 1.5 presents the summary statistics of the variables over the period.

Table 1.5: Summary Statistics Compustat

Variable	**Mean**	**Median**	**Std. Dev.**	**N**
Dividends	44.43	0	195.71	104381
Equity Issuance	21.81	.68	68.71	103368
Capital	863.10	23.52	3056.73	105516
Age	7.10	6	6.65	113580
Employment	8.36	.65	24.07	96425
Earnings	455.90	10.94	2429.87	104864

Source: Compustat North America

[30] Accesed at https://www.bea.gov/iTable/iTable.cfm?ReqID=9step=1reqid=9step=1isuri=1

[31] Though an imperfect measure of firms' age, it is the only one available in Compustat database. This variable presents a high correlation with actual age, so that can be used as a proxy.

We construct the variables used in the calibration as follows. The calibration targets are the average of these variables over the sample.

- **Employment growth**. Computed as $\frac{emp_{i,t}-emp_{i,t-1}}{(emp_{i,t}+emp_{i,t-1})/2}$.
- **Aggregate Investment rate**. Computed from NIPA table 1.1.5 and FAT table 1.1.
- **Aggregate Dividends to Earnings**. Measured as the sum of dividends of all firms alive in one period, divided by the sum their earnings (OIBDP).
- **Aggregate Equity to Investment**. Measured as the sum of equity issuance of all firms alive in one period, divided by the sum their earnings (OIBDP). Equity issuance of incumbents is the sum of equity issuance of all firms alive in one period that are not doing an IPO, and equity issuance of entrants the sum of equity issuance reporting to do an IPO in the period.
- **Aggregate Employment Growth by Age**. Computed as the sum of all labor of firms of age j at time t ($sum\_emp_{j,t}$) for all ages and years in our data. Then, compute the growth rates by age as $\frac{(sum\_emp_{j+1,t+1}-sum\_emp_{j,t})}{((sum\_emp_{j+1,t+1}+sum\_emp_{j,t})/2)}$, and averaging by age j across all years t in our sample.

Appendix B.2. SDC Global New Issues database

We use the Thompson's Securities Data Corporation (SDC) Global New Issues database. We only use the subset of observations from SDC that we can match to the previous Compustat observations through their CUSIP. We keep only those observations trading in main stocks markets: NYSE, Amex and NASDAQ (EXCHC codes NYSE Alter, NYSE Amex, NYSE Arca, NYSE MKT, Nasdaq). We use only primary offerings, since these are the ones linked to inflows of capital to the firm[32]. Following Lee et al. (1996), we compute the total costs of an issue as a percentage of the proceeds as follows:

$$\text{total cost} = GPCTP + EXPTH * 10/PROCDS \tag{1.52}$$

where the first item ($GPCTP$) is gross spreads (management fees, underwriting fees, and selling concession); and the second item ($EXPTH*10/PROCDS$) are other direct expenses (registration fee, printing, legal and auditing costs) as percentage of the proceeds .

[32] Secondary offerings are offerings of shareholders selling their existing shares, and therefore lead to no inflow of funds to the company.

Table 1.6: Summary Statistics SDC Platinum

		Mean	Median	Std Dev.	N
IPO	Gross Spreads	7.1	7	.16	1218
	Other Costs	4.0	3.0	2.9	994
	Total Costs	11.0	10.1	3.3	994
SEO	Gross Spreads	5.5	5.6	.2	1468
	Other Costs	1.5	0.8	2.2	1279
	Total Costs	7.0	6.6	3.0	1279

Appendix C Firms' Policies and their Life Cycle

The financial and investment policy of firms can be characterized using the FOC from the HJB. The Lagrangean associated to the maximization problem in the HJB equation can be written as:

$$= \frac{1-\tau_d}{1-\tau_g} d - e + \partial_k v(z,k)(x-\delta k) + \partial_z v(z,k)\mu z + \frac{(z\sigma)^2}{2}\partial_{zz} v(z,k) + \lambda_d d + \lambda_e e + ...$$
$$\lambda_k \left\{ (1-\tau_c)\pi(z,k) - x - \Psi\frac{x^2}{2k} - d + (1-\xi)e \right\},$$

where λ_k represents the shadow price of capital (Tobin's marginal q), λ_d and λ_e are the multipliers on the non-negativity condition on dividends and equity issuance. The optimal decisions on dividend distribution, equity issuance and investment should satisfy the following conditions:

$$d : \frac{1-\tau_d}{1-\tau_g} + \lambda_d - \lambda_k = 0 \tag{1.53}$$

$$e : -1 + \lambda_e - \lambda_k(1-\xi) = 0 \tag{1.54}$$

$$x : \partial_k v(z,k) - \lambda_k \left[1 + \Psi\frac{x}{k}\right] = 0 \tag{1.55}$$

$$KT : \lambda_d d = 0, \lambda_e e = 0, \lambda_d, \lambda_e, d, e \geq 0, \tag{1.56}$$

where (1.56) are the complementarity slackness conditions from Kuhn-Tucker.

The shadow price of capital (λ_k) determines the financial policy of the firm. It is easy to see that λ_k is bounded above by the cost of raising external funds ($\frac{1}{1-\xi}$) and bounded below by ($\frac{1-\tau_d}{1-\tau_g}$). In the former case the firm issues equity and in the latter case it distributes dividends. Tax policy (e.g. when $\tau_d \neq \tau_g$) and financial frictions create a wedge between these two bounds leading to an inaction region. Indeed, when the shadow value of capital is in between these two bounds the firm does not distribute dividends nor does it issue equity.

In this case, the firm finances all of its investment with retained earnings and all earnings are used to finance investment. Optimal investment satisfy:

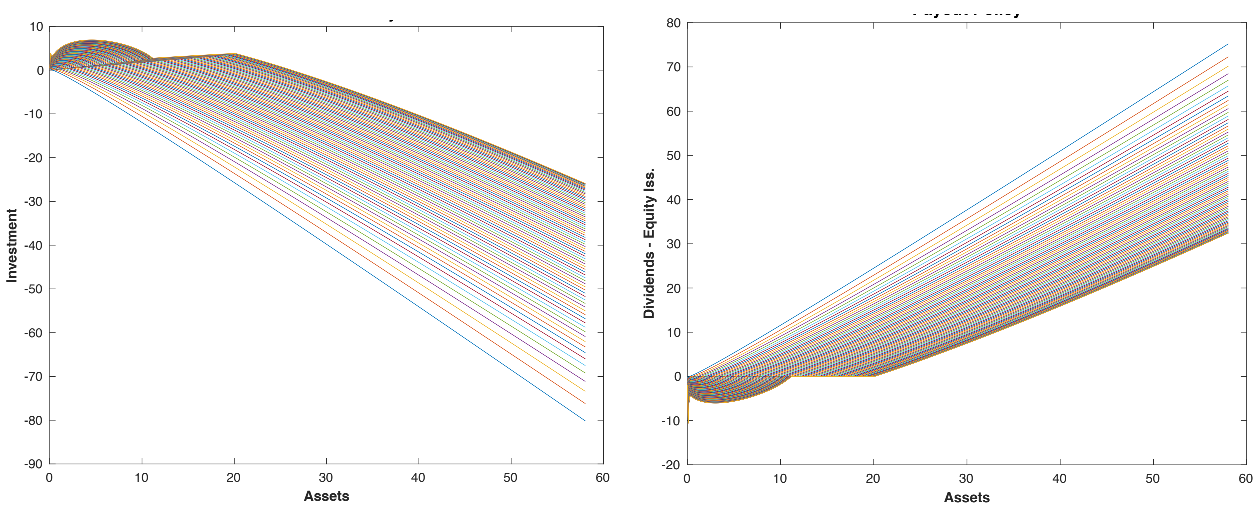
$$x = \left[\frac{\partial_k v(z,k)}{\lambda_k} - 1\right]\frac{k}{\Psi} \quad \text{where} \quad \lambda_k \in \left[\frac{1-\tau_d}{1-\tau_g}, \frac{1}{1-\xi}\right] \tag{1.57}$$

As in modern q theory, investment is an increasing function of the marginal value of installed capital. Financial frictions imply that investment is also affected by the shadow price of capital (λ_k). The rate of investment or disinvestment depends on the ratio between the marginal value of capital and the shadow cost of funds. If this ratio is above 1, investment rate is positive. If its below 1, the firm disinvests. For a fixed, marginal value of installed capital,the concavity of the value function implies that investment is a decreasing function of the shadow price of capital λ_k. The shadow cost of funds depends on the financial regime of the firm. When equity issuance is the marginal source of funds, $\lambda_k = \frac{1}{1-\xi}$. When the firm distributes dividends, $\lambda_k = \frac{1-\tau_d}{1-\tau_g}$ and the firm is indifferent between using the last unit of earnings to finance dividend distribution or investment. When $\lambda_k \in \left(\frac{1-\tau_d}{1-\tau_g}, \frac{1}{1-\xi}\right)$ firms do not issue equity nor distribute dividends. In this case, all available funds are used to finance investment.

Figure 1.4: Policy functions for different Z

A: Investment

B: Net Payout (Dividends-Equity)



Investment and payout policy (y-axis) by level of assets (x-axis) for different levels of productivity. Each parallel line corresponds to a level of productivity.

Figure 1.4 plots the investment and financial policy as a function of the capital installed by firms in our calibrated model economy. Each line in the figures correspond to a firm with different a level of productivity. It is instructive to consider the life cycle of a firm that enters the economy with a fixed productivity level z . If the initial level of installed capital is low enough, optimal investment is an inverted U-shaped function of capital (see Panel A). An increase in installed capital has two opposite effects on optimal investment (see equation (1.57)). On the one hand, the marginal value of capital to the firm decreases ($\partial_k v(z,k) \downarrow$), thereby pushing investment down. On the other hand, the presence of adjustment costs imply that the cost of investment decreases with the level of installed capital. This effect explains why the optimal level of investment initially rises with capital (as reflected by the positive effect that the term k outside the straight bracket in (1.57) has on x). The first force dominates at low levels of capital and the second force at high levels of capital, explaining the inverted U-shaped of investment as a function of capital. Note that a (young) firm with low level of capital finance investment by issuing equity (see Panel B). As capital increases, the firm makes more profits and can finance a bigger fraction of investment with retained earnings. The firm fully finances investment with retained earnings when installed capital becomes sufficiently large, thereby avoiding external financing costs. Once firms finance all investment with internal funds, the investment policy becomes an increasing function of installed capital (and earnings) until the firm reaches its optimal level of capital. This occurs when the level of capital is such that the shadow price of capital equates the after-tax value of dividend distribution to the shareholders. At this point, the firms starts distributing dividends. Higher values of installed capital then lead to higher dividend distribution and to lower investment. When installed capital is large enough, investment becomes negative as the firm finds it optimally to disinvest in order to finance dividend distribution.

Appendix D Robustness

Appendix D.1 Elasticity of Entry

The quantitative findings in Section 3.2 suggest that entry is quite responsive to changes in the taxation of capital income. It is interesting to study the sensitivity of the results to alternative ways of modelling entry. To this end, consider an alternative model economy in which entry costs depend on the wage rate as follows:

$$c_e = \bar{c}_e (w/w_b)^{\phi} \tag{1.58}$$

where $\bar{c}_e$ is the expected value of entering in the baseline pre-reform economy, and ϕ drives the elasticity of entry costs to changes in the wage rate. The calibrated baseline model economy features $\phi = 0$, and the pre-reform wage rate w_b is set to 1, so $c_e = \bar{c}_e$.[33] Now consider economies with $\phi = 1$ and $\phi = 2$. Note that a change in the parameter ϕ does not affect the cost of entry ($\bar{c}_e$). Hence, the pre-reform steady state of the economies with $\phi = 1, 2$ are observationally equivalent to the economy with $\phi = 0$, since $w/w_b = 1$. There is no need to recalibrate the alternative model economies since, by construction, they all match the calibration targets equally well.

Table 1.7 presents results and shows that ϕ matters importantly for the impact of tax reforms. As expected, the higher the value of ϕ, the lower the response of entry to changes in taxes. Focusing on Tax Reform 1, the increase in entry due to the elimination of the corporate income tax is 35.4% when $\phi = 0$ (baseline economy), 15.9% when $\phi = 1$, and 7.1% when $\phi = 2$. The increase in aggregate output ranges from 12.2% to 5.8%. Note that the tax reform has different effects on the average firm size across economies. While the average capital of firms decreases by 2.1% in the baseline economy, it increases by 11.6% when $\phi = 2$ and by 15.4% when entry is fixed. Table 1.7 shows that the response of entry also varies across economies in all the other tax reforms, though the range of variation in entry is the largest in the first tax reform. In general, the larger is ϕ the less important is the role of entry (extensive margin) and the more important is the variation in the average firm size (intensive margin).

Appendix D.2. Elasticity of Labor

To evaluate how adding an endogenous labor choice to the baseline model affect the results in the paper, assume that households have the following utility function

$$u(c, h) = log(c) - \phi \frac{h^{1+\gamma}}{1+\gamma}, \tag{1.59}$$

where γ is set so that the Frisch-elasticity of labor supply is 1/3. Using the values of consumption and wages in the economy with fixed labor supply under the US tax system, ϕ is set so that the representative household optimally chooses to supply $h = 1$ in the steady state of the model economy with endogenous labor supply. Moreover, the after tax interest rate is equal to the rate of time preference. Hence, the steady state of the model economy with endogenous labor supply is observationally equivalent to the one of the calibrated model economy and there is no need to recalibrate this economy. Table 1.8 reports how modelling endogenous labor supply affects the impact of eliminating the corporate income tax for the

[33] Given taxes, w and r we solve the firms' problem. The free entry condition pins down the value of the contant c_e and the mass of entry is obtained so that the labor market clears

Table 1.7: Effects of Tax Reforms for different Entry Elasticities

	Y	K	TFP	M_e	Wage	Value entr.	Value incu.	k_0	k	τ
Tax Reform 1: $\tau_c = 0$, financed by $\tau_d = \tau_g = \tau_r$										
ϕ=0	12.2	31.8	4.6	34.5	12.2	1.2	-0.8	5.5	-2.1	0.41
ϕ=1	8.0	23.7	2.3	15.9	8.0	8.4	7.7	9.7	6.8	0.45
ϕ=2	5.8	19.5	1.1	7.1	5.8	12.8	12.1	15.8	11.6	0.46
No Entry	3.7	15.4	0.0	0.0	3.7	16.3	15.6	19.3	15.4	0.48
Tax Reform 2: $\tau_c = 0.21$, financed by $\tau_d = \tau_g = \tau_r$										
ϕ=0	6.0	14.8	2.3	16.4	6.0	0.3	-0.7	1.3	-1.4	0.26
ϕ=1	3.9	11.1	1.2	7.8	3.9	4.1	3.6	4.7	3.1	0.29
ϕ=2	2.9	9.3	0.6	3.8	2.9	5.8	5.7	5.5	5.3	0.30
No Entry	1.9	7.5	0.0	0.0	1.9	7.5	7.7	6.3	7.5	0.31
Tax Reform 3: $\tau_c = 0.21$, financed by τ_d										
ϕ=0	-1.2	10.0	-3.6	-19.1	-1.2	-1.9	5.0	-9.1	36	0.39
ϕ=1	-0.5	10.8	-3.1	-16.5	-0.5	-2.3	4.1	-9.0	32.7	0.38
ϕ=2	-0.3	11.1	-2.9	-15.7	-0.3	-2.4	3.8	-9.0	31.8	0.37
No Entry	3.4	15.7	-0.4	0.0	3.4	-5.3	-2.1	-8.9	15.7	0.32
Tax Reform 4: $\tau_c = 0.21$, financed by τ_d, including a subsidy to entry τ										
ϕ=0	6.3	20.4	1.4	9.7	6.3	18.0	-6.1	137.3	9.8	0.29
ϕ=1	3.8	17.4	-0.3	-2.0	3.8	20.4	-2.2	141.7	19.8	0.33
ϕ=2	2.7	16.1	-1.1	-7.0	2.7	21.5	-0.4	144.3	24.8	0.34
No Entry	4.1	17.6	-0.2	0.0	4.1	20.0	-3.6	141.2	17.6	0.32

Percent changes from the baseline. From left to right: aggregate production (Y), aggregate capital (K), aggregate TFP (TFP), mass of entrants (M_e), average value of entrants gross of initial equity payment (Value entr.), average value of incumbents (Value incu.), average capital at entry (k_0) and average capital (k). In each experiment, we decrease corporate tax, but change other taxes τ such that the government revenue is constant. τ corresponds to the value of the tax rate being changed, specified in each line.

three model economies that differ in $\phi = 0, 1, 2$ and for the economy with fixed entry. The findings imply that entry is more responsive when labor is modelled as endogenous. Since in the three model economies with endogenous entry hours of work increase with the elimination of corporate income taxes, equilibrium in the labor market requires a larger mass of firm entry than in the economy with a fixed labor supply. Note that hours of work increase after the tax reform because the wage rate rises more than consumption (for all model economies). As a result, the substitution effect dominates the income effect on labor supply and hours increase in response to the tax reform.

Table 1.8: Tax Experiment with Elastic Labor Supply, $\tau_c = 0$, financed by $\tau_d = \tau_g = \tau_r$

	Y	K	TFP	M_e	Wage	Value entr.	Value incu.	k_0	k	Supply Labor	τ
ϕ=0	20.5	47.0	9.3	54.2	15.9	0.5	-2.4	-4.7	2.4	4.0	0.35
ϕ=1	13.0	32.9	5.0	24.7	10.0	9.9	8.4	9.2	6.6	2.7	0.41
ϕ=2	9.2	25.9	3.0	12.0	7.1	14.9	13.7	15.7	12.4	2.0	0.44
No Entry	5.2	18.1	0.8	0.0	3.7	19.5	18.7	20.4	18.1	1.4	0.47

Percent changes from the baseline. From left to right: aggregate production (Y), aggregate capital (K), aggregate TFP (TFP), mass of entrants (M_e), average value of entrants gross of initial equity payment (Value entr.), average value of incumbents (Value incu.), average capital at entry (k_0) and average capital (k). In each experiment, we decrease corporate tax, but change other taxes τ such that the government revenue is constant. τ corresponds to the value of the tax rate being changed, specified in each line.

Appendix D.3. AR(1) shock process

Our baseline economy assumes that productivity follows a geometric Brownian Motion. We now evaluate the robustness of our results by assessing the output gains of eliminating corporate income taxes in an economy in which productivity follows an AR(1) process. This specification is the one used by Gourio and Miao (2010) in their study of the effects of dividend taxation.

Calibration

The logarithm of productivity follows a diffusion process of the form:

$$dlnz_t = -\theta lnz_t dt + \sigma dW \tag{1.60}$$

which is the continuous time analog of an AR(1), where θ controls the mean reversion. From Ito's lemma, we obtain that

$$dz_t = z_t\left(-\theta lnz_t + \frac{\sigma^2}{2}\right)dt + \sigma z_t dW. \tag{1.61}$$

We assume that entrants draw productivity from the invariant distribution implied by the process above, which follows a lognormal distribution with $\mu = exp(-\theta lnz_t + \sigma^2/2)$ and variance σ^2.[34] We fix all parameters to the values in the baseline economy but for the following parameters: (i) ψ, determining the magnitude of capital adjustment costs; (ii) θ, determining the mean reversion of productivity; (iii) σ, determining the volatility of productivity shocks; (iv) ξ_e, determining equity issuance cost when firms enter the economy. We set $\theta = -log(0.76) = 0.2485$ to match the an autocorrelation of shocks of 0.76, as estimated in the Compustat data by Gourio and Miao (2010). The other three parameters are calibrated by targeting (i) the volatility of the investment rate x/k across firms of 0.059, (ii) the ratio of equity issuance by incumbent firms to investment of 12.6%, (iii) the fraction of businesses with less than 100 employees of 53%.

Table 1.9: Calibration Baseline Economy with AR(1) growth

Parameter	Description	Value
ψ	Capital adjustment cost	0.18
θ	Mean reversion parameter	0.2485
σ	Volatility of prod. shock	0.5
ξ_e	Financing cost at entry	0.40

The calibrated model economy with AR shocks matches well the calibration targets (see Table 1.10). Relative to our baseline economy, the calibration requires higher variance of shocks (0.50 instead of 0.15) and higher capital adjustment costs (0.18 instead of 0.09) to match the volatility of investment rates and the fraction of small businesses. These results are as expected: given that shocks are transitory we require a higher variance of shocks to match the heterogeneity in business size; and given the higher variance of shocks adjustment costs should also be larger in order to match the volatility of investment rates. Moreover, the higher adjustment costs calibrated implies that the model economy requires higher equity issuance costs at entry than in the baseline economy (0.40 instead of 0.30) to match the fraction of investment financed with equity by incumbent firms. The intuition is

[34] Since Gourio and Miao (2010) do not model entry and exit of firms, the distribution of productivity in their model economy is given by the invariant distribution of schocks.

simple: when adjustment costs are large, firms want to do more investment at entry in order to minimize adjustment costs after entry. Table 1.10 presents data in some non-targeted dimensions showing that the economy with mean-reverting shocks performs worse than our baseline economy. Relative to the data, the former model economy has a too low employment growth of firms (0.01 instead of 0.02), a too high autocorrelation of (annual) investment rates (0.71 instead of 0.57), and has almost no businesses with size bigger than 500 (while in the data they represent about 10% of the total mass of businesses).

Table 1.10: Calibration Results

	Data	Model
Targets		
Volatility investment rate	0.059	0.057
Eq. issuance incumbents/investment	0.13	0.13
Fract. bussinesses employees $\in [50, 99)$	0.53	0.52
Non-targeted dimensions		
Avg. employment growth	0.02	0.01
Autocorrelation invest. rate	0.57	0.71
Agg. eq. issuance /agg. investment	0.13	0.13
Dividend/ Earnings	0.098	0.46
Size Distribution of Businesses		
No. of Employees	Fraction Data	Fraction Model
$[50, 99)$	0.53	0.52
$[100, 249)$	0.29	0.45
$[250, 499)$	0.089	0.03
$[500, 999)$	0.0429	8e-7
$[1000, 2499)$	0.0265	0
$[2500, 4999)$	0.0099	0
$[5000, \infty)$	0.0115	0

Targeted moments in the data, and their respective counterpart in the model. Data comes from Compustat, and BDS for the size distribution of businesses.

Results

Table 1.11 presents the aggregate long-run effects of replacing the corporate income tax with a common tax on capital all forms of capital income (dividends, capital gains, interest income) that raises the same amount of government revenue. The quantitative findings are quite close to the ones in our baseline economy. Output increases by 15.5% and capital by

39%, while in the baseline economy these figures were slightly lower (12.2% and 31.8%). The elimination of corporate income taxation leads to a large increase in entry 47.6%, larger than the 34.5% increase in the baseline economy. As in the economy where shocks follow a geometric brownian motion, higher values of ϕ make entry less elastic, and the results of the tax reform on output and TFP are lower. We thus conclude that the key findings are robust to modeling productivity shocks as a mean reverting process.

Table 1.11: Economy with AR(1) shocks: Tax Reform setting $\tau_c = 0$, financed by $\tau_d = \tau_g = \tau_r$

	Y	K	TFP	M_e	Wage	Value entr.	Value incu.	k_0	k	τ
ϕ=0	15.5	38.9	6.2	47.6	15.5	1.0	-3.6	4.3	-5.9	0.38
ϕ=1	10.5	29.7	3.4	23.3	10.5	11.6	7.1	15.4	5.1	0.42
ϕ=2	7.8	24.7	1.9	11.9	7.8	17.4	13.1	21.3	11.4	0.44
No Entry	4.9	17.8	0.6	0.0	4.9	21.2	18.9	24.6	17.8	0.47

Percent changes from the baseline. From left to right: aggregate production (Y), aggregate capital (K), aggregate TFP (TFP), mass of entrants (M_e), average value of entrants gross of initial equity payment (Value entr.), average value of incumbents (Value incu.), average capital at entry (k_0) and average capital (k). In each experiment, we decrease corporate tax, but change other taxes τ such that the government revenue is constant. τ corresponds to the value of the tax rate being changed, specified in each line.

Chapter 2

Macroeconomics, Firm Dynamics and IPOs

2.1 Introduction

There have been several important changes in the US economic environment since the 1970s: a large decrease in corporate and dividend taxes (McGrattan and Prescott (2005)), an increase in financial development (Kim et al. (2008), Jayaratne and Strahan (1996)), and changes in idiosyncratic uncertainty (Bloom (2009), Gilchrist et al. (2014)). In this paper, I argue that these changes asymmetrically impact publicly traded and privately held firms since these firms are facing different financial frictions, hence they might react differently to changes in the economic environment. Acknowledging the difference between privately held and publicly traded firms, not only we can better understand how firms react to changes in the economic environment, but also the implications for selection (i.e. privately held firms deciding to do an IPO), and ultimately their impact on macroeconomic aggregates. Most papers studying heterogeneous firms focus on publicly traded firms (Cooley and Quadrini (2001), Gourio and Miao (2010)), i.e. firms with readily access to equity financing. Although publicly traded firms are important (they employ around one third of the population, and make up 40% of GDP), most firms are privately held and rarely use equity financing. Other papers study the behaviour of small operating units, or entrepreneurs (Buera et al. (2011)), who self-finance the firms, but do not take into account these large publicly traded firms. Some papers introduce in this setting a *corporate sector*, usually as a representative firm, but corporate and non-corporate firms only interact via general equilibrium (Quadrini (2000)). Here, I depart from the standard firm dynamics framework by modelling privately held firms that can endogenously do an IPO[1] and become publicly traded. The focus of this paper is threefold: 1) understanding the differential effect economic changes might have on privately held firms[2] (hereafter, private firms), and publicly traded firms (hereafter, public firms); 2) how these changes affect the endogenous IPO decision, and hence selection into publicly traded firms; and 3) their impact on macroeconomic aggregates.

The distinction between private and public firms is motivated by empirical evidence. Most private firms finance investment by issuing debt and reinvesting internal funds. Very few private firms issue equity, and those that do, equity is generally financed by the firm's owner/manager[3]. Meanwhile, there is around 26% of public firms financing with equity. There is theoretical (Auerbach (2002)) and empirical evidence (Becker et al. (2013)) pointing at the differential impact of taxes on firms financing with equity or internal resources. Hence, it is potentially important to take this distinction into account when assessing the aggregate impact of tax policies and other economic changes.

Furthermore, in the last decades the selection into public and characteristics of public firms have suffered major changes, but the reasons behind it are not yet well understood. From the 1970s until the 1990s, the number of public firms nearly doubled, and the market capitalization of domestic public companies went from nearly 54% of GDP in 1970 to almost 160% of GDP in 2000. After the beginning of the new century, the number of public firms decreased, but surprisingly the market capitalization to GDP was still high. A theory that connects private and public firms in a general equilibrium setting helps explaining how changes in the economic environment contribute to the observed trends and map out subsequent macroeconomic consequences.

The first contribution of this paper is introducing an explicit IPO decision in a general equilibrium model with heterogeneous private and public firms. In the model there is a fixed mass of firms that are heterogeneous in assets and productivity. They begin their lives as privately held. Production technology features decreasing returns to scale, and firms feature a life-cycle: they are created small due to financial frictions, grow, and eventually exit. They can finance operations either with debt subject to a collateral constraint, or with retained earnings. Each period, they can decide whether to do an IPO or not. At this decision point, they face a trade-off, as access to (costly) equity markets comes at the

[1] IPO, or Initial Public Offering, is the first time a company offers its shares to the public, and hence indicates the beginning of a publicly traded firm.

[2] I focus the study only on C-corporations, i.e. firms that face corporate taxes at the firm level, and distribution taxes at the personal level. Although commonly these are though to be almost 'synonymous' of large public firms, these are very heterogeneous: 65% of firms with C-corp status have yearly business receipts under $250,000; and the access to external equity of private c-corps is very similar to that of pass-through entities (see Appendix C.1).

[3] See C.1 for more details on the differences between public and private firms, and the IPO choice.

expense of a one-off fixed cost of IPO and a higher on-going cost of operation. This higher cost of operation captures the costs of being public, such as higher auditing cost, corporate governance regulations or principal-agent problems, that this paper abstracts from modelling. Firms deciding to do an IPO are those that are constrained since they can benefit from the extra financing they obtain when they are public. When firms have accumulated enough assets, the costs of going public outweight the benefits, and firms remain private. Thus, as in the real world, the rich dynamics of the model give rise to the existence of large privately held firms (such as Cargill). The publicly traded status is therefore history-dependent since it depends on the stream of shocks the firm received during its life cycle. I calibrate the model to match key moments of the distribution of public and private firms between 1970-1980, aimed at capturing the skewness of the firm distribution. The model macthes reasonably well some non-targeted moments, and it replicates the dynamics of TFP around the IPO date found in the data by Chemmanur et al. (2009).

The second contribution of the paper is showing how changes in the economic environment impact privately held and publicly traded firms' policies, and the selection into publicly traded firms (IPO choice). More precisely, I analyze how much of the changes observed in the data can be explained in the model through exogenous changes in the economic environment, and ultimately what the macroeconomic impact of these changes is. First, I show that only changes in corporate and dividend taxes from the 1970s to the 1990s can explain more than half of the increase in stock market capitalization to GDP, and goes a long way explaining changes in payout, investment, and savings policy of publicly traded firms. It also helps explaining the changes in selection , i.e. type of firms doing IPO. Second, I show that changes in taxes, although they imply changes in policies that are still in line with the data, produce counterfactual selection into public (IPO choice) patterns in the 2000s. I explore some of the possible changes that might be behind this trend, namely changes in the cost of being public, better access to credit, and changes in the idiosyncratic shock process, and analize their impact in firms' behaviour, selection into IPO, and macroeconomic aggregates.

In the first part of the quantitative analysis, I show that the observed changes from the 1970s to the 1990s in corporate and distribution taxes[4] incentivize IPOs, increasing

[4]I focus only on changes in distribution taxes and corporate taxes, and set aside capital gains tax and income taxes. The first reason is that they did not suffer major changes: according to TAXSIM, capital gains tax increased 4pp from the 70s to the 90s, and then decrease 5pp from the 90s to the 00s; while taxes paid on interest decreased 4pp in the first subperiod, and remained fairly constant in the second subperiod. The second reason is related to the problem studied here. Since there is no organizational choice here (pass-through vs c-corp), income taxes only affect firms through the stochastic discount rate of the household, hence they are not as interesting for the firm dynamics patterns. Capital gains taxes might have important effects on the payout policy and investment decisions of firms. Modelling it correctly, i.e. capital gains being taxed at realization, involves a great deal of complexity, and it is out of the scope of this paper. A simpler way of modelling it into a firm dynamics framework is assuming this tax paid every period: i.e.

the number of public firms and its stock market value (*stock market boom*). Consistent with the data, more firms go public, the median size at IPO decreases and the dispersion of employment at IPO increases. Changes in taxes correctly predict an increase in the use of external equity, an increase of the equity issued, and a decrease in the fractions of firms making distributions (Fama and French (2001)[5]). The model also correctly predicts an increase in investment and a higher stock of savings of firms (Sánchez et al. (2013)). Furthermore, it predicts an increase in concentration, consistent with the evidence presented by Autor et al. (2017). Introducing private and public firms connected by the IPO decision amplifies the macroeconomic impact of these regulations, and its assymmetric impact in private and public firms makes concentration increase more than it would have if we do not take this distinction into account. The mechanism at work is as follows: a decrease in corporate taxes makes investment in private and publicly traded firms less distorted, and allows a faster accumulation of resources, thereby decreasing the tightness of the financing constraint. Ceteris paribus, this affects private and public firms symmetrically, but it benefits more constrained firms, as they have more after-tax profits to reinvest and they can undo financing constraints faster. While lower corporate tax increases the market value of public firms, it also increases the value of keeping the firm private. Conversely, distribution taxes have an asymmetric effect on public and private firms. After a decrease in distribution taxes, the external equity financing becomes cheaper. The incentives to go public increase for constrained firms, who find it profitable due to the lower cost of external financing. In equilibrium, after the decrease in taxes, selection into public tilts towards immature firms. These firms issue more equity and invest more proportionally than their mature counterparts. The fraction of firms distributing dividends then decreases, consistent with the pattern observed in the data. Changes in taxes also affect public mature firms. When hit by a good productivity shock, they use more equity and invest more. Since there is less misallocation and firms can outgrow constraints faster, output increases 3.2% and TFP increases 0.9%. Without this selection mechanism (i.e. if all firms are publicly traded), the increase in stock market capitalization to GDP would be half[6]. Boosted by the differential

every period all firms are sold and bought, and capital gains on this sale are taxed every period. Although more technincally convenient, this gives rise to the question of its comparability to the real world, even more when we are studying privately held firms, which hardly ever sell the shares of their company. In Appendix D.4 I introduce a full set of taxes, understanding capital gains tax in this way, and find that results do not change significantly.

[5] Fama and French (2001) point to the selection channel, i.e. new listings changing the composition of publicly traded firms towards small firms with low profitability and strong growth opportunities. Interestingly, they also find that, regardless of their characteristics, firms have become less likely to pay dividends.

[6] McGrattan and Prescott (2005) already pointed at the importance of taxes and regulations for the boom in market valuation of corporations. They focus on a neoclassical growth model, and aim to explain the increase in market value of all corporations (private and public). They study a larger set of changes

impact of the policy in private and public firms, there is an increase in the concentration of employment, with the top largest 1% firms increasing their employment share by 1.6%. Direct costs of issuing equity also decreased in this period. However, I show that changes in taxes have a larger impact in the selection and behaviour trends of publicly traded firms.

In the second part of the quantitative analysis, I show that changes in taxes alone cannot explain the changes in selection patterns since the 2000s. I explore how the interaction of changes in taxes with other changes in the economic environment, namely the cost of being public, idiosyncratic uncertainty (idiosyncratic shock process) and financial development (access to credit), affect firms' payout and investment policies, the IPO choice, and how these affect macroeconomic aggregates. I show that an increase in the cost of being public, one of the most common explanations behind the decrease in the number of IPOs since the 2000s, is at odds with many changes in the selection patterns (firms doing IPOs), and behaviour of publicly traded firms. Greater access to credit cannot explain either these changes, nor most of the changes in behaviour of public firms, but have important macroeconomic implications. Finally, changes in the shock process (higher persistence and volatility of the shock) make less productive firms decide against an IPO. This channel can rationalize the decrease in the number of IPOs and the number of public firms, together with an increase in the market capitalization to GDP, and it is consistent with most of the changes in behaviour observed in the data. These changes also have large macroeconomic implications since there are larger and more productive firms in the economy, and it is an important driver for the increase in corporate savings. Although this channel (changes in the idiosyncratic shock process) is the change most in line with the data, none of these changes can account for the full story. Arguably, it is a mix of these that is driving the overall results, together with two important changes that happened in this period that my model cannot account for: the increase in mergers and acquisitions (M&As) and the increase in private capital financing.

Literature Review and Contribution

This paper relates to and adds upon the literature surrounding the effect of taxes, financing frictions, and uncertainty on firms' choices. Many researchers have devoted effort to understanding the effects of *taxes* on corporate financing policy in the Finance literature. Modigliani and Miller (1958) showed that, under certain assumptions, neither financing policy nor payout policy influenced the value of the firm. However, in the presence of distortions, such as taxes, this theorem no longer holds. Auerbach (2002) reviews the effect of corporate and dividend taxes in equity policy, debt-equity decisions, and choices regarding ownership

in regulations, but they abstract from firm heterogeneity and the assymmetric impact of these policies in public and private firms.

structure and organizational form. One key finding of this literature is that the effect of distribution taxes depends on the financing policy of the firm. Under the 'new view', firms finance investment marginally with retained earnings, and dividend taxation is irrelevant for their investment choices. Under the 'traditional view', firms finance investment marginally with equity issuance, and in this case dividend taxation does distort investment decisions. Corporate taxes are distortive, without regard to the financing source. Korinek and Stiglitz (2009) model the life cycle of firms, arguing that firms change their financing source depending on the stage of their life cycle, and use their model to analyze the impact of permanent and unexpected dividend tax changes. Becker et al. (2013) use a panel of firms from different countries and empirically study the impact of distributions tax changes on firm's investment policies. They find support for the previous theoretical findings: high distribution taxes favor investment of firms able to finance with retained earnings. A decrease in the distribution tax changes the allocation of capital from firms in the 'new view' (with the capacity to finance investment with retained earnings) towards firms in the 'traditional view' (firms financing with external equity). Macroeconomists have also studied the impact of taxes on investment decisions of firms, and how these can affect macroeconomic aggregates. For example, McGrattan and Prescott (2005) explore how the changes in taxes during the 1980s in the US and UK can account for most of the rise in corporate equity values relative to GDP in these countries. Other papers study optimal Ramsey taxation of firms, as Conesa and Domínguez (2013), who find that the optimal long-run policy features zero corporate taxes and positive dividend taxes, with labor and dividend taxes being identical. However, until recently, most studies were focusing in representative firms models, abstracting from heterogeneity. Gourio and Miao (2010) and Gourio and Miao (2011) study the long run and transitional effects of dividend and capital gains taxation on aggregate capital with a continuum of firms subject to idiosyncratic productivity shocks. Erosa and González (2018) study the aggregate effects of a full set of capital income taxes (corporate tax, dividend tax, capital gains tax and personal tax) with heterogeneous firms featuring endogenous entry and life cycle, and find that each tax has different assymmetric effects throughout the firms' life cycle, affecting investment, entry choices, and macroeconomic aggregates. Finally, Anagnostopoulos et al. (2017) study the aggregate and distributional effects of reforms that replace corporate profit taxes with dividend taxes in a model that features both household and firm heterogeneity. Other papers focus on the effect of changes in the economic environment on specific firm behaviour, such as firms' savings or financing choices (Armenter and Hnatkovska (2017), Macnamara (2019)). Whereas most papers focus on public firms, my paper contributes to this strand of literature by studying how private and public firms are affected differently by changes in the economic environment, and how these changes affect the IPO, leading to a potentially differential effect on their macroeconomic impact. I abstract from other mechanisms through which these taxes can affect macroeconomic aggregates, such as the legal form of organization (Dyrda et al. (2018), Chen et al. (2017)).

This paper also relates to the literature dealing with *financing frictions*. In Finance, focus generally lies on the modelling and measuring of financing costs (both equity and debt). The existence of market imperfections that create a wedge between the cost of internal and external funds is widely accepted, departing again from the assumptions of the Modigliani-Miller theorem. Thus, great effort is made towards understanding and measuring the effect of financing frictions. For example, Lee et al. (1996) measure direct (underwriting and other fees) and indirect (underpricing) costs of equity issuance at IPO. Hennessy and Whited (2007) use the simulated method of moments in a dynamic model to infer the magnitude of financing costs. In Macroeconomics, much attention is given to financing frictions, from the point of view of the entrepreneurs (agents operating small firms), or the firms (usually large firms with access to equity issuance). For instance, Quadrini (2000) or Cagetti and De Nardi (2006) analyze the wealth income distribution using models of occupational choice, where agents can decide whether to work, or to start their own (small) firm, and a representative large firm represents a non-entrepreneurial (corporate) sector. Papers like Erosa (2001) or Buera et al. (2011) analyze the effect of financing frictions on TFP, focusing on them as a source of misallocation, where entrepreneurs acting as producing units decide whether to work or to operate an entrepreneurial firm. Other papers focus on the effect of financing frictions on different aspects of firm dynamics, such as Cooley and Quadrini (2001) or Caggese and Cuñat (2013). Jermann and Quadrini (2007) use a model with heterogeneous firms featuring financing frictions to demonstrate that the mere prospect of high future productivity growth experienced during the 1990s can generate sizable gains in current productivity, as well as a stock market boom. Very few papers study how frictions can have a differential effect on private and public firms. Zetlin-Jones and Shourideh (2017) study how financial shocks affect private (risk averse) firms and public (risk neutral) firms asymmetrically, and how this can affect the macroeconomic implications of financial shocks. Thesmar and Thoenig (2011) explain the divergence in volatility trends of public and private firms by an increase in the stock market participation and better risk sharing. Neither have endogenous IPO choice, i.e. the mass of private and public firms is fixed. The contribution of this paper is to introduce both private and public firms, and explicitly model their transition by the IPO decision. Privately held and publicly traded firms face different financial frictions. While both can finance via debt and retained earnings, the former cannot issue equity[7]. This creates rich

[7]Realize this is equivalent to understanding the IPO as the extensive margin decision of the option of issuing equity.

firm dynamics, creating also predictions on the impact on the IPO choice.

This paper also relates to the strand of literature dealing with the effects of *uncertainty* on investment and macroeconomic aggregates. Bloom (2009) studies the impact of uncertainty shocks in real variables, and finds that after an increase in uncertainty, hiring and investment 'freeze'. Gilchrist et al. (2014) find that the impact of uncertainty shocks occurs primarily through financial distortions. While their focus is on the effect of uncertainty fluctuations over the business cycle, this paper focuses on the long run effects of changes in uncertainty, understood as changes in the idiosyncratic productivity shock process faced by firms.

Finally, this paper draws upon the literature dealing with IPOs. In this paper, an IPO is modelled in a reduced form way since the focus is on its macroeconomic implications, and therefore abstracts from many of the phenomena studied in this literature, such as underpricing (see Ritter and Welch (2002) for a review). Clementi (2002) uses a firm dynamics framework with private entrepreneurs that do IPOs, to explain the empirical patterns observed around the IPO date in a partial equilibrium framework.

The rest of the paper is organized as follows. Section 2.2 documents the changes in selection and behaviour of public firms. Section 2.3, presents the model and explains the IPO decision. Section 2.4 explains the estimation estrategy, and describes the fit of the baseline model. Section 2.5 shows the quantitative experiments, where Section 2.5.1 presents the effect of changes in taxes from the 1970s to the 1990s and explores its implications, and Section 2.5.2 explores the effects of a wide set of economic changes covering the whole period from the 1970s to the 2000s: taxes, costs of being public, access to debt, and the idiosyncratic shock process. Section 2.6 concludes.

2.2 Empirical Evidence

This section reviews the main changes in the IPO choice and the publicly traded firms' behaviour since the 1970s to the 2000s in the US. Since I am interested in the long term effect of changes in the economic environment, and in order to avoid capturing business cycle movements, I separate the data in three periods: 1970-1980, 1990-2000, and 2000-2008. I document the following facts, comparing the 1990-2000 and 2000-2008 to the '*baseline*' 1970-1980:

1. The number of publicly traded firms and IPOs increases after the first period, and decreases afterwards in the third period.

Table 2.1: Main statistics

	1970s	**1990s**	**2000s**
Selection & Composition			
Avg size public	7.90	5.67	7.99
Median size at IPO	0.35	0.20	0.25
p75 to p25 emp at IPO	7.11	11.56	40.57
Median age at IPO	9	8	8
Stock Market cap to GDP	0.42	0.97	1.22
Tobin's Q	1.73	3.60	2.65
Behaviour Public			
Fraction firms eq> 0	0.12	0.30	0.30
Distribution to sales	0.02	0.03	0.04
Equity to sales	0.07	0.74	0.80
Investment to sales	0.07	0.14	0.15
Financial Assets to Assets	0.32	0.40	0.42
Volatility emp. Growth public	0.14	0.20	0.19

Source: Compustat. Averages over a ten year window. Variables are winsorized at 1%. For more information about data construction, see Appendix A. Size refers to number of employees in thousands. Volatility of employment growth computed as in Comin and Philippon (2005). Age at IPO from Ritter. Financial Assets to assets is the ratio of financial assets to overall assets.

2. There is an increase in dispersion of firm size at the IPO stage in both periods, and the stock market capitalization to GDP increases.

3. Publicly traded firms' payout and investment policies follow the same trend over time: more firms are using equity, and the average equity to sales increase. Firms are investing more, making more distributions, and increasing their corporate savings.

Table 2.1 shows statistics regarding the composition, payout and investment behaviour of firms, and Figure 2.1 plots the number of publicly traded firms and number of IPOs by year. From the 1970s to the 1990s, there was a '*stock market boom*'. The number of publicly traded firms increased significantly since the 1970s to the 1990s, partly caused by the increase in the number of IPOs[8], that went from 71 in 1980 to 677 in 1996[9]. The characteristics of

[8]Number of IPOs from Jay Ritter's website. Accessed at `https://site.warrington.ufl.edu/ritter/files/2018/04/FoundingDates.pdf`.

[9]Exit rates (firms exiting the 'public pool', either because the close, they are acquired or they revert to

firms doing IPOs were also different: they were more dispersed in size (employees), smaller, and slightly younger. I call these *changes in selection*. Because of this increase of IPOs, the share of public firms (as a percentage of overall firms) increased 25%, and the number of public firms nearly doubled. Meanwhile, average size of public firms, measured in employees, decreased 28%. All these changes made the market capitalization of the 'pool' of public firms increase a stunning 130%, and the aggregate Tobin's Q also increased 114%, pointing at a higher valuation of firms or an improved used of resources[10].

Regarding publicly traded firms' behaviour, they used equity as a source of financing more frequently, and used it more intensively: the fraction of firms issuing equity increased 158%, and average equity to sales increased nearly ten times. Firms were making more distribution[11], and investing more intensively. Financial assets to overall assets, a measure of the stock of savings of a firm, increased 25%[12]. Also, volatility of employment growth of publicly traded firms increased 39%. Papers like Comin and Philippon (2005) and Davis et al. (2006) document the increase of volatility of public firms[13], and attribute it to deregulations, increased used of R&D, or changes in selection into public.

However, these changes could be due just to composition effects, i.e. a higher share of entrants in the publicly traded pool, or by shifts in the underlying industry composition. If firms entering are now smaller, younger, and more constrained, it could be that these firms invest more (proportionally), and use more equity to finance this growth, driving up all the statistics just analyzed. Appendix A.2 decomposes these trends by industry, by entrants (firms doing IPO in the previous five years) and incumbents, and shows further statistics that might be informative, i.e. evolution of the median, standard deviations and employment-weighted measures. All the measures confirm the trends presented here: an increase in the

private) also increased, but not enough to offset the increase in entry. See a more detailed description of entry and exit rates into publicly traded in Appendix A.2

[10] A shift towards industries that use intangible capital more intensively can also partly explain this trend.

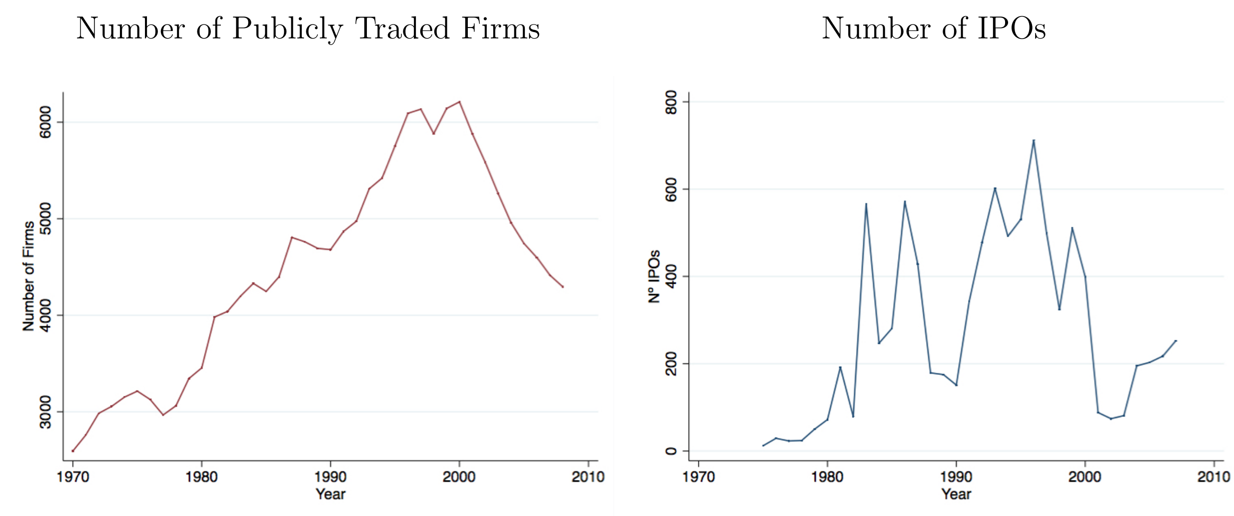
[11] Throughout the paper, I use the term distribution to refer to cash dividends plus share repurchases. Since in this paper I do not present a good theory on why firms distribute dividends and/or share repurchases, I focus on the overall cash distributions. Trends for cash dividends are presented in Appendix A.2.

[12] This increase in corporate savings is documented by several papers. There are several measures to understand how the stock of savings evolves. Armenter and Hnatkovska (2017) use net financial assets to capital; Di Nola (2017) use the stock of cash holdings. Some other papers focus on savings as a flow, see for instance Chen et al. (2017). Throughout the paper, I use the stock of financial assets to overal assets, i.e. the sum of cash holdings, other current assets and accounts receivables to overall assets. Appendix A.1 describes in more detail how it is computed in the model and the data. Appendix A.2 shows the trends for these alternative ways of measuring savings, and they all follow a similar pattern.

[13] Davis et al. (2006) a phenomenom they call 'volatility convergence'. While volatility of private firms is larger than volatility of public firms, from the 1970s to 2000 volatility of private firms was decreasing, while that of public firms was increasing. They attribute the decrease of volatility of private firms to shifts towards older and larger businesses. The model I present here is not well suited to capture this, and hence is not suitable to explain the trend observed in private firms.

extensive and intensive margin of equity issuance, increase in distributions and investment, and a higher stock of savings.

Figure 2.1: Trends in Publicly Traded Firms



Source: Number of IPOs by year from Ritter's website. Number of publicly traded firms from Compustat.

What happened after 2000? There seems to be a reversal in the selection patterns previously described. The number of IPOs drops, decreasing entry, and decreasing the number of public firms. Median size at IPO increases again, while the dispersion of employment at this stage increases significantly. Average size of public firms is larger, with the average firm in the period having 7986 workers. Surprisingly, even if the pool of public firms shrinks, the market capitalization to GDP kept rising during this period, which means the stock market value of public firms increased significantly during the period. Seeing these reversal in selection patterns, if changes in behaviour would be driven just by entrants, we would expect this trends to revert somehow towards their 1970s values. However, this is not the case. If anything, they are issuing more equity, making more distributions and investing more heavily than in the 1990s, while their stock of savings and volatility remains pretty much unchanged. Hence, although selection patterns revert in this period, the market value of firms and their behaviour does not experience this 'reversion'.

Although these empirical patterns have been studied separately in the literature, to the best of my knowledge this is the first paper developing a framework that attempts to rationalize these facts in a firm dynamics setting with endogenous IPO choice. In the next sections, I construct a model of heterogeneous private and publicly traded firms, and ask whether some of the changes in the economic environment witnessed in this period (changes in taxes, equity issuance costs, costs of being public, idiosyncratic shock process and access to debt)[14] can reconcile (or not) the trends observed in the data regarding the selection of firms into publicly traded, their behaviour, and what their macroeconomic consequences are.

2.3 Model

I consider an infinite horizon model in discrete time, t=0,1,2,... Each period is a year, and there is no aggregate uncertainty. The economy is populated by a representative household, who supplies labor inelastically, a fixed mass Υ of heterogeneous privately held and publicly traded firms, and a government. Firms are characterized by its permanent component of productivity θ, the level of transitory productivity z, its capital k and its level of debt b. To simplify notation, call the vector of idiosyncratic states $x \equiv \{\theta, z, k, b\}$. There are two main differences between privately held and publicly traded firms. First, publicly traded firms can access the equity markets, while privately held cannot. This feature captures that private firms do most of their financing with retained earnings or debt, since accessing the equity markets is very costly due mainly to information assymmetries[15]. Second, publicly traded firms need to pay a fixed cost of operation, whereas privately traded firms do not. This costs captures the higher ongoing costs of publicly traded firms, such as annual reports, auditing, SEC filings, etc. The household is the final owner of all firms, since she owns two funds: the *private capital fund*[16], which is comprised of all private firms; and the *mutual fund*, comprised of all public firms.

Firms start as privately held. They draw the permanent component of productivity θ and the transitory component of productivity z. Before taking the draw, the household, through the private capital fund, finances its initial operation. Because of information assymmetries, the private capital fund does not observe the type of the firm, and faces a high

[14] Evidence regarding changes in the economic environment (taxes, equity issuance costs, access to debt) is presented in Appendix A.

[15] This is a simplification, since some private firms do have access to private capital or venture capital funds, but captures the difficulty private firms have finding outside investors for their projects, due to monitoring difficulties of private firms. Very few firms use external equity financing for financing operations, and those that do, mostly raise equity from the owners (see Appendix C.1.1). When a firm raises money from its owner, we can think of the firm as an entrepreneur operating a technology and deciding to invest in his company: as long as he is constrained, changes in the external cost of equity will not have a large impact in the investment of the firm. I discuss the evolution of venture capital backed firms, and their behaviour around the IPO, in Section C.1.3

[16] Note that we are assuming that private firms are risk neutral. However, there is evidence pointing at the poor diversification of private firms (Moskowitz and Vissing-Jorgensen (2002)), so it is likely that private firms, when owned by an undiversified owner, exhibit risk aversion. This would give the IPO an extra value, since private firms are getting rid of the inherent risk of the firm. I include this in a reduced form in this paper, by assuming that private firms need to distribute as dividends at least a fraction ε of after tax perofits. Modelling explicitly this feature would require a more complex model. A version of the model including this is available upon request. Preliminary, I find the qualitative results are similar.

cost of external financing, so the firm is not funded optimally. Every period, they operate, decide how much to reinvest and how much to distribute as dividends, but they cannot issue external equity again. At the end of the period, the exit shock and the productivity shock are realized. After this, the firm can decide whether to remain private, or to begin the following period as a public firm by doing an IPO. If it decides to do an IPO, the private capital obtains the proceeds of the IPO, and the company is acquired by the mutual fund. The trade-off faced at the IPO decision is access to (costly) equity markets, at the expense of a fixed cost of IPO and a higher on-going cost of operation. In Appendix C.1 I show evidence supporting this trade-off in the data.

Publicly traded firms produce, decide how much to invest, how much to distribute as dividends, and how much equity to issue at the beginning of the period. At the end of the period, the exit shock and the productivity shock are realized, and after this, they can decide whether to exit or not before next period begins. After exogenous exit (private and publicly traded firms) or endogenous exit (publicly traded firms), new firms will replace the exiting ones starting as privately held.

Technology

Both privately held and publicly traded firms have access to same technology function

$$y = exp(z+\theta)\left(k^{\alpha}n^{1-\alpha}\right)^{\varrho}, \tag{2.1}$$

where k is the amount of capital, and n the labor used in production. The parameter $\varrho < 1$ controls the degree of returns to scale.

Financing

Firms can finance themselves via three different ways: retained earnings, borrowing funds, or equity issuance. The only difference between privately held and publicly traded is that the latter cannot issue equity. The firm can save ((b can be negative) or borrow, but there is a borrowing constraint such that $b \leq \gamma k$, with $0 \leq \gamma \leq 1$ [17].

The budget constraint of privately held firms and publicly traded are (2.2) and (2.3) respectively, where d and e have non-negativity constraints, and $\xi(e)$ is the equity issuance cost.

$$d + k' - b' = (1-\tau_c)(y - wn) + (1-(1-\tau_c)\delta)k - (1+(1-\tau_c)r)b \tag{2.2}$$

[17] For the sake of simplicity, I assume the parameter governing the borrowing constraint is the same for private and public firms.

$$d - e + \xi(e) + k' - b' + (1-\tau_c)\kappa = (1-\tau_c)(y - wn) + (1 - (1-\tau_c)\delta)k - (1 + (1-\tau_c)r)b \quad (2.3)$$

The budget constraints are identical but for two ingredients: public firms can issue equity, subject to equity issuance costs, and they have to pay an operation cost κ. Substituting for the optimal n given k, and rearranging, we obtain in the right-hand side the following term, and call it cash on hand $m(x)$:

$$m(x) = (1-\tau_c)\pi(x) + k - b \quad (2.4)$$

where profits $\pi(x)$ are as follows:

$$\pi(x) = \Phi(w) k^{\frac{\alpha}{1-(1-\alpha)\varrho}} exp(z+\theta)^{\frac{1}{1-(1-\alpha)\varrho}} - \delta k - rb \quad (2.5)$$

and $\Phi(w)$[18] is a function of the wage and parameters. I introduce a slight different timing assumption to simplify the state space[19]. Let's introduce a new variable, called net worth a, i.e. $a = k - b$. Throughout the paper, I also refer to net worth as assets, with a slight abuse of notation[20]. The timing assumption is that the firm chooses a' inter-period, and then intra-period decides how to allocate the net worth available a between capital k and debt (or savings) b, taking into account the borrowing constraint. This timing convention allows to simplify the idiosyncratic state space of the firms, which now is $x \equiv \{\theta, z, a\}$. Introducing this, and subsituting $b = k - a$, we obtain that firms maximize profits intra-period:

$$\pi(x) = \max_k \Phi(w) k^{\frac{\alpha}{1-(1-\alpha)\varrho}} exp(z+\theta)^{\frac{1}{1-(1-\alpha)\varrho}} - \delta k - r(k-a) \quad (2.6)$$

$$\text{s.t. } k \leq \phi a \quad (2.7)$$

with $\phi = \frac{1}{1-\gamma} \geq 1$. The solution of this problem[21] is:

$$k^*(x) = \begin{cases} k^{unc}(\theta, z) & \text{if } k^{unc}(\theta, z) \leq \phi a \\ \phi a & \text{if } k^{unc}(\theta, z) > \phi a \end{cases} \quad (2.8)$$

18 $\Phi(w) = \frac{w}{(1-\alpha)\varrho}^{\frac{1}{(1-\alpha)\varrho - 1}} \left(\frac{w}{(1-\alpha)\varrho}^{(1-\alpha)\varrho} - w \right)$

19 This timing is made on the spirit of Buera and Moll (2015)

20 Note that the model equivalet to total assets, as they appear in the balance sheet of firms, is $at = max(a, k)$.

21 $k^{unc}(\theta, z) = \left(\frac{r+\delta}{\varrho \alpha exp(z+\theta)} \right)^{\frac{\varrho(1-\alpha)-1}{1-\varrho}} \left(\frac{w}{\varrho(1-\alpha) exp(z+\theta)} \right)^{-\frac{\varrho(1-\alpha)}{1-\varrho}}$

There are two reasons why the borrowing constraint might not be binding in equilibrium: getting a negative productivity shock, and '*precautionary savings*'. Note that, in a world with no uncertainty, the optimal choice of net worth a' for next period would be such that the firm is constrained, i.e. $a' = k^{unc}(\theta, z)/\phi$, since there is a tax advantage to debt. However, when introducing uncertainty, there will be a precautionary savings motive for hoarding assets if the firm expects its productivity to grow in the future, since internal financing is cheaper than external financing, and the borrowing constraint might be optimally not binding.

2.3.1 Private Firms

Private firms maximize the stream of dividends received by the private capital fund, subject to their borrowing constraint. They cannot issue equity, $e = 0$. The problem they solve is the following:

$$W(\theta, z, a) = \max_{\{d,a'\}} (1-\tau_d)d + \beta(1-\varsigma)E\left[max\{W(\theta, z', a'), W^{IPO}(\theta, z', a')\}\right]$$

$$\text{s.t. } d + a' = (1-\tau_c)\pi(\theta, z, a) + a \tag{2.9}$$

$$d \geq \varepsilon(1-\tau_c)\pi(\theta, z, a) \tag{2.10}$$

They choose d and investment to maximize the future stream of dividends. Then, the death shock ς and the productivity shock z' realize. After that, the firm can choose whether to do an IPO and start the following period as public, or whether to remain privately held. To formalize other frictions that affect privately held firms, I assume they need to distribute at least a fraction ε of their after-tax profits. The purpose of this is twofold. Firstly, it is a simple way of modelling in a reduced-form the low diversification of privately held firms (Moskowitz and Vissing-Jorgensen (2002)), and hence the need to smooth dividends[22]. Secondly, this parameter is key in matching the speed at which firms can undo financing frictions, and therefore the speed at which they can grow before they do an IPO[23].

[22] Just think of a regular model with entrepreneurs owning the private firm with concave utility function (i.e. featuring risk aversion). The need for consumption smoothing will force the firm to distribute dividends every period.

[23] In Appendix D.3 I do a sensitivity analysis setting $\varepsilon = 0$. All results remain qualitatively unchanged.

IPO

An IPO is when a private firm raises capital by offering its stock to the public for the first time. The main purpose of an IPO is to raise capital for investment. Going public has different costs: direct, such as underwriting fees, legal fees,etc.; and indirect, such as underpricing, principal-agent problems, disclosure of public information, etc. In Appendix C.1 I explain in detail how the process of an IPO works. In the model, the IPO occurs at the beginning of the period, before production takes place.

I model an IPO in a reduced form way as a fixed cost that needs to be paid upfront, i.e. before the IPO takes place. Paying it upfront prevents firms with very low assets to do an IPO, even if their productivity is very high and they are very constrained. This is in line with the listing requirements imposed by many listing exchanges, which do not allow firms not meeting certain thresholds to list[24]. The value of doing an IPO is therefore the value of the firm being publicly traded, after the IPO cost is paid:

$$W^{IPO}(\theta, z, a) = V(\theta, z, a - \xi_0) \tag{2.11}$$

In order to keep tractability, I assume that the private capital fund transfers the whole ownership of the firm to the mutual fund. Note that this assumption is without loss of generality: since the final owner of the private capital fund and the mutual fund is the household, the pricing and the discount factor will be the same, and hence the objective function of the firm does not change with the share of equity the private fund keeps.

Once the firm is public, it can decide how much equity to issue. The cost of doing an IPO is therefore the fixed cost of the IPO, plus the equity issuance costs of the equity issued during the first period as public, so that the overall cost of the IPO expressed as a spread of the equity issued is:

$$\text{Cost IPO} = \frac{\xi_0 + \xi(e(\theta, z, a))}{e(\theta, z, a)} \tag{2.12}$$

2.3.2 Public Firms

Public firms maximize profits, subject to their borrowing constraint. They can issue equity e, but subject to equity issuance costs $\xi(e)$. They have to pay a fixed cost every period, $\kappa > 0$. This fixed cost represents the higher costs of operating as a public firm, such as auditing costs, reporting costs, etc. Note that because of this fixed cost of operation, it might be the

[24]Firms that want to trade their shares in stock exchanges need to meet a set of minimum requirements. For instance, to trade in NASDAQ Global Markets firms need to have income from continuing operations before income taxes (in latest fiscal year or in two of last three fiscal years) of at least \$1,000,000, and have a market value of publicly traded shares of \$8,000,000 to qualify for trading.

case that firms want to exit the economy if they receive a bad productivity shock and the value of continuing operations falls below zero. Firms can only distribute positive profits, i.e. $d \geq 0$, and cannot do share repurchases, i.e. $e \geq 0$[25].

$$V(\theta, z, a) = \max_{\{d,e,a'\}} (1-\tau_d)d - e + \beta(1-\varsigma)E\left[max\{V(\theta, z', a'), 0\}\right]$$

$$\text{s.t. } d - e + \xi(e) + a' = (1-\tau_c)(\pi(\theta, z, a) - \kappa) + a \tag{2.13}$$

$$d \geq 0; e \geq 0 \tag{2.14}$$

2.3.3 Entry and Exit

Entry in the model is exogenous, since the mass of firms that enters replaces those exiting. Firms start as private. When they are born, they draw a fixed component of productivity θ and a transitory component z, which will evolve over time. This implies ex-ante heterogeneity, i.e. permanent productivity θ and draw of z; and ex-post heterogeneity, i.e. posterior realizations of z after entry[26]. Private capital fund, who provides financing only at the early stage of their life, know the distribution of entrants, but they do not know the type θ or productivity z before making the initial investment. The amount of financing provided to each firm is then given by:

$$a_{\text{init}} = argmax\{E\left[W^{PR}(\theta, z, a_{\text{init}})\right] - a_{\text{init}} - \vartheta a_{\text{init}}^2\} \tag{2.15}$$

The cost of financing the firm, $\vartheta a_{\text{init}}^2$, aims to capture frictions that make the private capital fund give less funding than optimal.

There is exogenous exit in the model, given by ς, and endogenous exit of publicly traded firms, since they have to pay a fixed cost of operation that might make the expected

[25]Some authors allow for share repurchases (see for instance, Gourio and Miao (2011). Share repurchases are taxed at capital gains tax, but dividends are taxed at income tax. If $\tau_g < \tau_d$, firms would only make distributions via share repurchases. To avoid this, these models impose an exogenous lower bound. In this case firms will always start making distributions via share repurchases, until they reach the limit, and from that point they make the rest of the distributions as dividends. Comparing it to the framework presented here, firms would start making distributions earlier (via share repurchases), while not distributing dividends. However, for firms distributing dividends, the overall distribution is the same, and the only thing that changes is its 'label'. This is true even in the presence of capital gains taxes, as long as $\tau_d > \tau_g$. When estimating the distribution tax, I take into account the amount of share repurchases and its different taxation, computing therefore an estimate of the overall tax on distributions, i.e. dividends and share repurchases. See Appendix B.1.

[26]This is in line with findings of Pugsley et al. (2018). Using micro data for the US, they provide evidence that ex-ante differences in the growth potential of firms accounts for most of the size heterogeneity across firms of a given age.

continuation value negative. Firms exiting are replaced by a new firm with new draws of ability and productivity.

2.3.4 Timing

The timing of the problem is as depicted in Figure 2.2. At the very beginning of the period, and before operation takes place, private firms decide whether to do an IPO or remain private, and publicly traded firms decide whether to exit or not. Privately held or publicly traded firms that received the exogenous exit shock at the end of last period also exit the economy. At the same moment, firms replacing those exiting (exogenously or endogenously) enter the economy. Next, all firms operate, and make the payout and investment decisions. After all these decisions are made, firms receive the shock to productivity, and the exogenous exit shock.

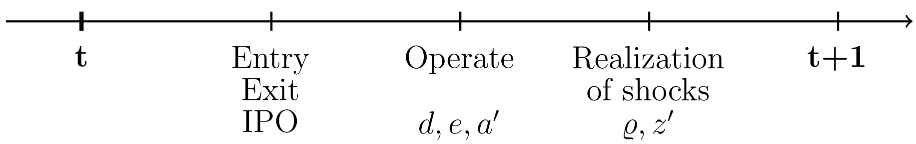


Figure 2.2: Timing of the Problem

2.3.5 Government

Government tranfers to consumers in a lump-sum way the receipts of taxes.

$$T_t = \int (\tau_d d_t^{PU}(x_t) + \tau_c \pi_t(x_t)) d\mu_t^{PU} + \int (\tau_d d_t^{PR}(x_t) + \tau_c \pi_t(x_t)) d\mu_t^{PR} \tag{2.16}$$

2.3.6 Household

There is a continuum of homogeneous workers, characterized by a representative household. Every period, they supply their work $\bar{L}$ inelastically. They decide how much to consume, C, and how much to save in the the risk-free asset, A_{t+1}, the shares φ_{t+1} they own of the mutual fund composed by all public firms, and the shares of the private capital fund they own ψ_{t+1}.

$$\max_{\{C,\varphi_{t+1},\psi_{t+1},A_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t U(C)$$

$$C_t + \varphi_{t+1}\Omega_t^{PU} + \psi_{t+1}\Omega_t^{PR} + A_{t+1} = \tag{2.17}$$

$$\varphi_t(D_t^{PU} + \Omega_t^{PU} - P_t^{IPO}) + \psi_t(D_t^{PR} + \Omega_t^{PR} + P_t^{IPO} - E_t) + (r_t A_t + w_t \bar{L}) + A_t + T_t, \tag{2.18}$$

where the net dividends received from the public firms conforming the mutual fund and from private firms in the private capital fund, respectively, are defined as:

$$D^{PU}{}_t = \int \left((1-\tau_d)d_t^{PU}(x_t) - e_t(x_t)\right) d\mu_t^{PU} \tag{2.19}$$

$$D^{PR}{}_t = \int \left((1-\tau_d)d_t^{PR}(x_t)\right) d\mu_t^{PR} \tag{2.20}$$

The ex-dividend price of the mutual fund and the private capital fund valued at time t, with pricing kernel m_t, is

$$\Omega_t^{PU} = m_t(1-\varsigma)\int E[V_{t+1}(x_{t+1})]d\mu_t^{PU} \tag{2.21}$$

$$\Omega_t^{PR} = m_t(1-\varsigma)\int E[W_{t+1}(x_{t+1})]d\mu_t^{PR} \tag{2.22}$$

The cost of acquiring new firms for the mutual fund at the IPO (P^{IPO}) is received by the private capital fund[27]. E_t is the cost of financing new entrants, i.e.

$$E_t = M_{et}\int_\theta \int_z a_{\text{init}}(\theta,z) + \vartheta a_{\text{init}}(\theta,z)^2 dF_z dF_\theta \tag{2.23}$$

$$P_t^{IPO} = \int I_{IPO}(x_t)V_t(\theta,z,a-\xi_0)d\tilde{\mu}_t^{PR} \tag{2.24}$$

$$\tag{2.25}$$

where M_{et} is the (exogenous) mass of entrants, that replace firms exiting the economy; $\tilde{\mu}_t^{PR}$ is the distribution of firms at the beginning of the period, i.e. before entry or IPO decisions take place.

There is no aggregate uncertainty, and since there is a continuum of private and publicly traded firms, the problem of the household is deterministic. I focus in steady state, where all

[27] Remember the fixed cost is paid by the firm right before doing the IPO, and this is included in the price of the firm at the IPO.

allocations are constant, so I can drop the time subscripts. In equilibrium, households own all the shares of the private capital and the mutual fund, and the pricing kernel is $m = \frac{1}{1+r}$. Hence, in steady state, consumption of the representative household is given by her budget constraint.

$$C = D^{PR} + D^{PU} + rA^{HH} + w\bar{L} + T - E \tag{2.26}$$

2.3.7 Equilibrium

Given taxes τ_d, τ_c, entry costs ϑ, and equity issuance costs $\xi(e)$; a stationary recursive competitive equilibrium consists on aggregate prices $\Theta = \{w, r\}$, policies for privately held firms $(d^{pr}, a^{pr\prime}, l, k, I_{IPO})$, policies for publicly traded firms $(d^{pu}, e^{pu}, a^{pu\prime}, l, k, I_s)$, aggregate level of consumption for the household C, and distributions over idiosyncratic states (μ^{PR}, μ^{PU}) such that:

1. **Privately held firms.** Given prices, taxes, and equity issuance costs, $\{d^{pr}, a^{pr\prime}, l, k, I_{IPO}\}$ solve the private firm's problem (2.9).

2. **Publicly traded firms.** Given prices, taxes, and equity issuance costs,$\{d^{pu}, e^{pu}, a^{pu\prime}, l, k, I_s\}$ solve the publicly traded firm problem (2.13).

3. **Household** consumption is given by (2.26).

4. **Government's** budget constraint (2.16) is satisfied (all tax revenue is rebated back to consumers as a lump sum transfer).

5. Given prices, taxes, equity issuance costs, and optimal policies, the distribution of private firms μ^{PR} and of publicly traded firms μ^{PU} is stationary.

6. Labor and assets market clears.

$$\text{Labor}: \quad \sum_{j \in \{PR,PU\}} \int l(\theta, z, a) d\mu^j = \bar{L} \tag{2.27}$$

$$\text{Capital}: \quad \sum_{j \in \{PR,PU\}} \int a(\theta, z, a) d\mu^j + A^{HH} = \sum_{j \in \{PR,PU\}} \int k(\theta, z, a) d\mu^j \tag{2.28}$$

2.3.8 Discussion

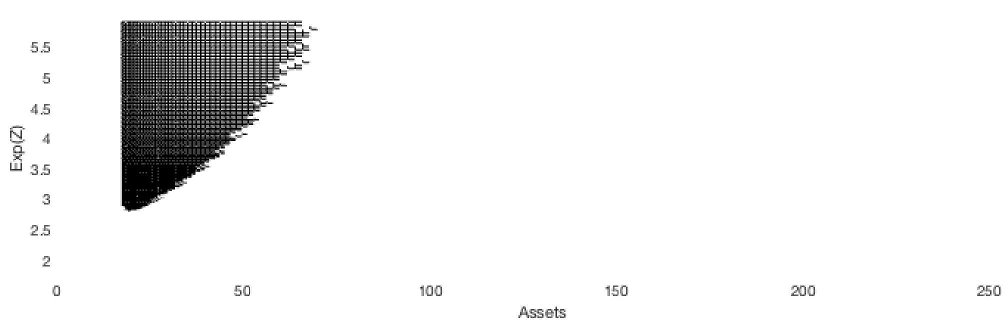
IPO decision

The IPO choice depends on the permanent level of productivity θ, the level of transitory productivity z and its stochastic process, and the amount of net worth a the firm has. The advantage of going public is having access to (costly) equity issuance, and therefore reducing the financing constraints. The disadvantages are having to pay a one-off cost ξ_0, and a going-on cost κ ever after. Hence, the decision depends on how much constrained the firm is, and how much constrained it expects to be in the future.

Only firms with high permanent type θ will go public. They are more constrained, benefit more from equity issuance, and they can afford the on-going fixed cost of operation[28].

Figure 2.3 depicts the IPO choice (in black) of privately held firms, for a high constant value of θ, with net worth a in the x-axis and the transitory component of productivity $exp(z)$ in the y-axis. Firms with very low net worth cannot go public, no matter what their productivity is, since they must be able to pay the fixed cost of IPO ξ_0 up-front. This generates a *lower threshold* for the amount of net worth at IPO. Firms with high level of net worth never go public, no matter what their transitory productivity is. They are very large and unconstrained, and paying the fixed and on-going costs of being public is not worth it.

Figure 2.3: IPO choice for $\rho_z = 0.8$, $\sigma_z = 0.23$, $\kappa = 5.5$, $\eta_0 = 17.1$



Assets in X axis, transitory shock exp(z) in Y axis, $exp(\theta) = 2.4$ fixed. Firms going public in black, firms staying privately held in white. $\eta_1 = 0.12$.

Firms deciding to go public are those that have relatively low net worth compared to their productivity: they are very constrained, so they benefit a lot from the extra

[28] Those with low θ will never do an IPO, even if it were free ($\xi_0 = 0$), because the on-going costs are too high for them.

finance if they go public. They expect to maintain the positive shock for a long period since the process of the shock is persistent, so it is worth for them to go through the IPO process. Appendix D.3 shows the IPO choice for alternative parametrizations of the model. Expectations about future productivity, i.e. persistence and volatility of the shock, matter when the firm decides to do an IPO. The firm will weigh in how constrained it is now, and the possibility of being constrained in the future, which is governed by the productivity process. The firm decides to do an IPO when the benefits of increased access to financing outweight the costs involved in the IPO process. This gives rise to rich dynamics for the IPO decision.

The IPO choice is history-dependent. To see this, think of a firm starting with a low transitory shock and low net worth. If the subsequent shocks it receives are positive shocks, the firm will begin growing and accumulating net worth, eventually reaching the shaded area and deciding to do an IPO. If the firm receives initially a bad stream of shocks (below the long run mean value), it continues reinvesting its profits and doing 'precautionary savings', since the firm expects its productivity to grow in the long run. If the firm was able to accumulate enough net worth before they finally receive a high productivity shock, the costs of doing an IPO at that moment might outweight its benefits, so it remains private. Hence, the model allows the existence of large privately held firms, such as Cargill in the US[29]. In sum, as happens in the US, not all large irms are publicly traded.

The Effect of Taxes on Optimal Decisions

It is key to understand the effect of taxes on policies and the value of firms to understand the mechanism through which taxes impact the IPO decision. Think of two identical firms, with the sole difference that one is public and the other one is private. Corporate taxes distort both privately and publicly traded firms. Since investment is not tax deductable, corporate taxes create a wedge in the euler equation, lowering investment. Ceteris paribus, lower corporate income tax have two effects. First, it increases optimal size at maturity. Secondly, it allows constrained firms to grow faster, since they have more after-tax profits to reinvest in the firm. Hence, this tax distorts more *constrained* firms than unconstrained, no matter whether they are private or public.

However, distribution taxes affect differently private and public firms. Private firms are under the 'new view': they always finance at the margin with internal resources, so

[29] Cargill is the largest privately held company in the US, with 160,000 employees and revenues of nearly $115 billions.

distribution taxation does not affect the investment decision of incumbents. Publicly traded firms can be under the 'new view' or the 'traditional view' depending on their stage at the life cycle. If they are constrained and are therefore issuing equity, they fall under the 'traditional view', and the distribution tax distorts their investment decisions by increasing the cost of external funds. If the firm is financing investment internally with retained funds, or is already mature and it is distributing dividends, then they fall under the 'new view', and the distribution tax does not distort their decisions. Market value of privately held and publicly traded firms do depend on distribution taxation, since it is simply the discounted stream of future dividends, so it also impacts the proceeds at IPO. In sum, this tax distorts more *public firms* accessing the equity markets, and the IPO value of the firm.

This differential effect of the same taxes on firms is the key mechanism explaining the changes in selection and behaviour of publicly traded firms after a change in corporate and dividend taxes. As a result, the share of private and public firms can be key in determining the aggregate efects of tax policy changes. For a more detailed explanation about the effect of taxes on optimal decisions, see Appendix C.2.

2.4 Estimation

I estimate the baseline model to match key moments of the US economy during 1970-80. First, I need to assume some functional forms for the transitory productivity process and the equity issuance costs. Then, I describe the data used, and describe the three set of parameters of the model: directly assigned, externally estimated, and estimated within the model. Finally, I show the model fit and perform some validation exercises.

Productivity process

The component of productivity follows an AR(1)

$$z_{t+1} = \rho_z z_t + \epsilon_t; \text{ where } \epsilon_t \sim N(0, \sigma_z) \tag{2.29}$$

I discretize this process with a twenty-point discrete Markov chain using the method developed by Tauchen (1986).

Equity Issuance Costs

I parametrize the cost of issuing equity to be linear in equity issued:

$$\xi(e) = \xi_1 e$$

This specification, together with the fixed cost of issuing equity at IPO (see equation (2.12)), implies that equity issuance cost at IPO presents economies of scale, and IPO costs will be higher than those of seasoned offerings, in line with data presented by Lee et al. (1996).

Distributions

Upon entry, firms draw the transitory productivity component z from the stationary distribution of the previously described AR(1) process. The fixed productivity component θ is drawn from a Pareto distribution:

$$F_\theta(exp(\theta)) = \begin{cases} 1 - \left(\frac{\theta_{min}}{exp(\theta)}\right)^\eta & \text{if } exp(\theta) > \theta_{min} \\ 0 \text{ otherwise.} \end{cases} \tag{2.30}$$

The tail of the Pareto distribution, η, is key for matching the skewness of the size distribution of firms. The fixed component of productivity θ is discretized into six grid points.

Data Sources

I use several data sources for estimating the model[30]. The main data source is Compustat North America, a panel of publicly traded firms with balance sheet and cash flow data. I complement this with Thomson Reuter's Securities Data Company (SDC) Platinum, a dataset with information about the issuance of securities and the costs associated with these. I also use the Business Dynamics Statistics, a publicly available dataset with annual aggregate statistics describing firm startups, job creation and destruction by firm size and age. The data on age at IPO is obtained from Jay Ritter's website[31]. Finally, I complement these with data from Davis et al. (2006),

[30] See Appendix A.1 for a more detailed description of the data used.
[31] https://site.warrington.ufl.edu/ritter/ipo-data/

which provides data comparing publicly traded and privately held firms from LBD from the 1970s to the 1990s. Finally, tax rates are computed with data from NIPA and TAXSIM, adjusted with other datasets, as explained in Appendix B.1.

2.4.1 Assigned Parameters

I set the discount rate to match the equilibrium interest rate of $r = 0.04$. Following Gilchrist et al. (2014), I set the share of capital $\alpha = 0.3$. Capital depreciation is set to 6%. Exogenous exit is set to $\zeta = 0.02$, which implies an average life of a firm of 50 years. The minimum theta, θ_{min}, is set to 0.3, so that the productivity shocks are relevant for all permanent types[32].

Table 2.2: Assigned Parameters

Parameter		**Value**	**Def./Source**
Assigned parameters			
Share of capital	α	0.3	
Capital depreciation	δ	0.06	
Discount factor	β	0.9615	Risk-free interet rate of 0.04
Exogenous exit rate	ζ	0.02	Exp.life of public firms 50 years
Minimum θ	θ_{min}	0.3	See text

Parameters assigned in the baseline calibration and their targets.

2.4.2 Parameters estimated without solving the model

To estimate these parameters, I use the structure of the model and the data available without the need of solving the model. Corporate taxes are fixed at 35.4%, and distribution taxes at 34.9%. Equity issuance costs, expressed as a spread of overall equity issuance, amounts to 12%. For a more detailed description of how I set these parameters, see Appendix B.1 and Appendix B.2.

To estimate the degree of returns to scale, and the process of the transitory productivity shock, I use data from Compustat following the estimation procedure described in Appendix B.3[33]. I estimate a decreasing returns to scale parameter very close to 0.85,

[32] If the values for the permanent type θ is too high with respect to the transitory shocks z, there is no action coming from idiosyncratic uncertainty. If the values for the permanent type θ are too small, then this fixed heterogeneity doesn't play any role, and the IPO choice is given only by the transitory component. θ_{min} is chosen such that both play a role in the IPO choice.

[33] The identification assumption here is that privately held and publicly traded firms follow the same process for idiosyncratic shocks, an assumption also made in the model.

so I set $\varrho = 0.85$. This value is in between the values estimated by Burnside et al. (1995), who find estimates between 0.8 and 0.9, and has been used extensively in this literature (Midrigan and Xu (2014), Jermann and Quadrini (2007)). I estimate the shock process with data from 1970-80, and find the persistence of the shock to be $\rho_z = 0.80$ and the standard deviation of the shock $\sigma_z = 0.23$. The estimates are in line with those found in the literature (see for instance Gourio and Miao (2010)). However, since the shock process is important for the IPO decision, I carry out sensitivity analysis with respect to these parameters in Appendix D.3.

Table 2.3: Parameters estimated without solving the model.

Parameter		**Value**	**Source**
Frictions			
Corporate Income tax	τ_c	35.4	NIPA
Distribution Tax	τ_d	34.9	TAXSIM
Equity Issuance Costs	ξ_1	12	SDC
Technology and shock process			
Decreasing returns	ϱ	0.85	Compustat
Persistence of prod. Shock z	ρ_z	0.8	" "
Std. Deviation z	σ_z	0.23	" "

Parameters estimated without solving the model, as explained in Appendix B.1 (taxes), Appendix B.2 (equity issuance costs) and Appendix B.3 (decresing resturns and shock process).

2.4.3 Parameters estimated by solving the model

I estimate the remaining six parameters by minimizing the weighted sum of squared residuals between a set of moments computed in the model, $m(\Theta)$, and in the data, $\tilde{m}$. Table 2.4 shows the estimated parameters and their values, the targeted moments and the model performance.

Although all the moments are jointly determined in general equilibrium and are thus affected by changes in all the parameters, some parameters are specially relevant for matching certain moments. In order to match the first three moments of Table 2.4, the skewness of the firm distribution is key. The tail of the distribution η, which is estimated to be 3.3, together with the cost of operation κ and the fixed cost of doing an

IPO ξ_0, match the employment share of public firms (29%), the share of publicly traded firms (0.12%), and is close to matching the employment share of largest 2% firms (61% in the data, compared to 63% in the model). The cost of operation κ is estimated to be 5.5, which implies a 1.2% of the average output of public firms in the baseline economy. The fixed cost of going public, ξ_0, is 17.1 in the baseline economy, a cost equivalent to 11.1% of the average equity issued at IPO. This means the overall cost of IPO is 23%, slightly higher than that found in the data (See Table 2.5 of non-targeted moments). The main reason for this is that this fixed cost is capturing other non-measurable costs my model abstracts from, like underpricing at IPO, internal cost of the preparation of IPO, etc. The parameter determining the tightness of the borrowing constraint ϕ is set to 1.35, which implies an average debt to assets ratio of public firms of 0.19. The parameter governing the cost of entry ϑ, is set to 0.6. This parameter is closely related to the average incumbent firms' employment growth: size at entry determines firm growth over the life cycle. This cost implies an average size of start-ups which is around 11% of that of incumbents, which is broadly consistent with the US data for the manufacturing and business service sector reported by OECD (2001). Finally, the dividend smoothing parameter, ε, which is 0.3 in the calibration, determines the speed at which constrained firms can accumulate resources, and it is important determining the median age of the firm when it does IPO.

Table 2.4: Targeted moments

	Data 70s	**Baseline**	**Param.**	**Descr.**	**Value**
Employment share public firms	29%	29%	κ	Fixed cost public	5.5
Share of public firms	0.12%	0.12%	ξ_0	Fixed cost IPO	17.1
Emp. Share of top 2%	61%	63%	η	Tail of Pareto dist.	3.3
Firm emp. Growth	1.70%	1.70%	ϑ	Cost of initial fin.	0.6
Av. Debt to assets public firms	0.19	0.19	ϕ	Borrowing constraint	1.35
Median age at IPO	9	9	ε	Dividend smoothing	0.3

First two moments are from Davis et al. (2006) for the year 1980. Next two moments are from BDS. Since only data from 1977 is available at BDS, these targets are computed as averages from 1977 to 1985. Next moment computed from Compustat are averages over 1970-1980 from the sample including domestic manufacturing firms with variables winsorized at 1%, and constructed as explained in Appendix A. Last moment from Ritter database for the year 1980.

2.4.4 Validation of the Model

To explore further implications of the baseline model, I conduct some validation exercises. First, I compare some non-targeted moments of publicly traded firms to the data, and then show the same moments for privately held firms in the model. Second, I compare the dynamics of TFP around the IPO date to the data, and confirm the good match.

Non-targeted moments

Table 2.5 shows further statistics with their data counterpart. The model matches reasonably well the average size of privately held and publicly traded firms, which is another check confirming the good match of the distribution of firms of the model, particularly the relationship between publicly traded and privately held firms. Average employment at IPO to average employment of publicly traded firms is 0.14 in the data and 0.22 in the model, implying that firms doing IPO in the model are larger than in the data. Stock market capitalization to GDP is 64% in the model, 22 pp higher than in the data. Tobin's Q is higher in the model than in the data, 1.49 versus 1.39.

Table 2.5: Non-Targeted moments

	Data 70s	Model	Source
Composition & Selection			
Ratio av. size public to av. size private	323	339	Davis et al. (2006)
Av. spread at IPO	18%	23%	Lee et al. (1996)
Relative emp. at IPO to public	0.14	0.22	Compustat
p75 to p25 emp. at IPO	7.1	2.1	Compustat
Stock Stock market cap. To GDP	0.42	0.64	Compustat
Tobin's Q	1.39	1.49	Compustat
Behaviour			
Fraction firms eq> 0	0.12	0.13	Compustat
Distribution to sales	0.02	1.4	Compustat
Equity to sales	0.07	0.16	Compustat
Investment to sales	0.07	0.41	Compustat
Financial Assets to Assets	0.32	0.28	Compustat
Emp. Growth public	3.3%	3.5%	Compustat

All moments are averages in the period 1970-1980. Unless otherwise noted, moments refer to publicly traded firms. Moments computed from Compustat are averages over 1970-1980 from the sample including domestic firms with variables winsorized at 1%, and constructed as explained in Appendix A. Tobin's Q, measured as the aggregate market value of firms to aggregate capital, obtaining therefore a capital weighted average ratio.

The share of firms doing equity issuance is 0.12 in the model, and 0.13 in the data. The model overpredicts dividend, equity issuance to sales, and investment to sales. Due to the parsimoniousness of the model, there are some moments that cannot be targeted. There are no adjustments costs in real variables, and equity issuance costs are linear, which makes equity to sales in the model higher than in the data: when firms receive a shock, they issue a lot of equity to adjust as fast as possible. Dividends here are obtained as a 'residual'[34], i.e. the remaining funds after all the profitable investments are exhausted, so the model cannot match the smoothing of dividends present in the data. This makes distributions to sales larger in the model than in the data. With no adjustment costs on capital, investment to sales is also overstated in the model. Financial assets (FA) to total assets, a measure of the stock of savings of the firm, is 0.32, very close to the 0.33 in the data[35]. Although not reported Table 2.5, the volatility of employment growth of private firms is larger than that of public firms (0.89 versus 0.82). This is in line with empirical evidence showing that private firms are more volatile than publicly traded firms (see, for instance, Davis et al. (2006)).

Dynamics around IPO

Next, I evaluate whether the dynamics of firms around the IPO in the model is alligned to what we find in the data. Chemmanur et al. (2009) use the Longitudinal Research Database (LRD) to understand the behaviour of firms around the IPO date. They find that: 1)Firms larger in size and with higher sales growth are more likely to go public; 2) TFP exhibits an inverted U-shape around IPO; 3) Sales and employment increase both prior and after IPO. To understand whether the model is in line with these findings, I run some tests on a simulation of 10,000 firms in the baseline economy.

First, I run a simple probit regression of the indicator of a firm doing an IPO on size (sales), employment growth, and age. I find that coefficients on size and employment growth are both positive (0.0008 and 0.25 respectively) and statistically significant at 1%, and the coefficient on age is positive but statistically insignificant. Hence, in the model firms larger in size and with higher growth rates are more likely to go public, just as in the data.

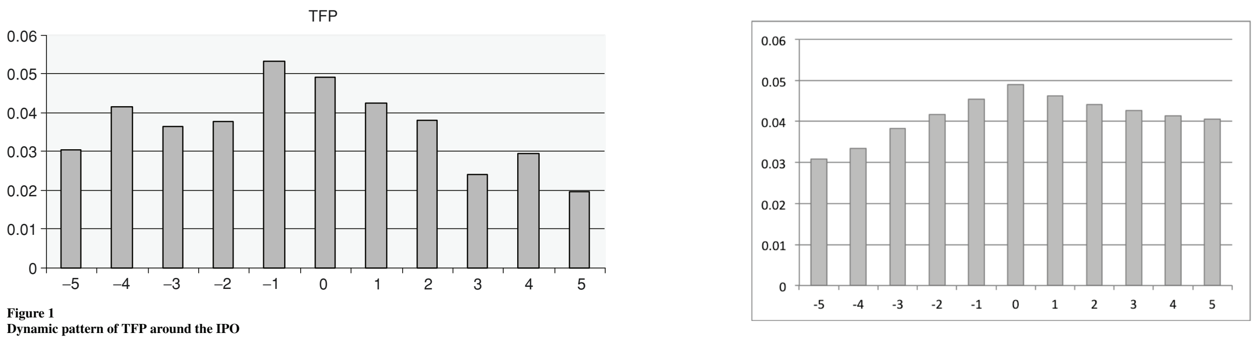
Secondly, I want to test the dynamics of TFP around the IPO. Chemmanur et al. (2009) compute TFP for firms going public, in each of the five years prior to becoming public, and each of the five years after doing an IPO. In the left panels of Figure 2.4, the findings of their paper are depicted. In the right panel of the same figure, I show the same picture obtained with the simulated firms of the model, where I normalize

[34] Some papers in the literature fix this by imposing a dividend smoothing function for the firm, but it is not used here for the sake of simplicity.

[35] Net financial assets, on the other hand, are larger in the model than in the data. This is because firms in the data are holding at the same time large amounts of financial assets and financial liabilities, somthing the model cannot capture.

the values at IPO to be the same as those in the data for the sake of comparison. The inverse U-shape relationship of TFP around the IPO date is replicated by the model. The reason for this inverse U-shape is the decreasing returns to scale technology of firms [36], together with the mean reversion of the productivity process. After a of good productivity shock, the firm is very constrained, so TFP increases. After a series of good productivity shocks, the firm is so much in need for funds that decides to do an IPO. Once they are already public, and with the chance of using equity financing, they increase their operations. Due to the decreasing returns to scale technology, and the shock process slowly tending towards its long run average, TFP starts decreasing after IPO. Sales and employment are growing before and after the IPO.

Figure 2.4: Dynamics around IPO



Average TFP five years before and after IPO. Left: Findings from Chemmanur et al. (2009). Right: Findings from a simulation of 10,000 firms in the baseline model. Value at IPO (t=0) normalized to that of the data.

2.5 Quantitative Analysis

2.5.1 Changes in Taxes and the Stock Market Boom in the 1990s

In this section, I show that only the changes in taxes observed in the US from the 1970s to the 1990s (see Table 2.6) can explain more than half of the increase in stock market capitalization to GDP of the period, predicting an increase in IPOs and changes in payout and investment policies that are consistent with the data. This has important macroeconomic implications, which differ from the ones in a model with only private or only public firms.

[36] See Clementi (2002) for more details on this.

Table 2.6: Exogenous Changes

	70s	→	90s	Source
τ_c	35.4		28.9	See Appendix B.1
τ_d	34.9		20	See Appendix B.1

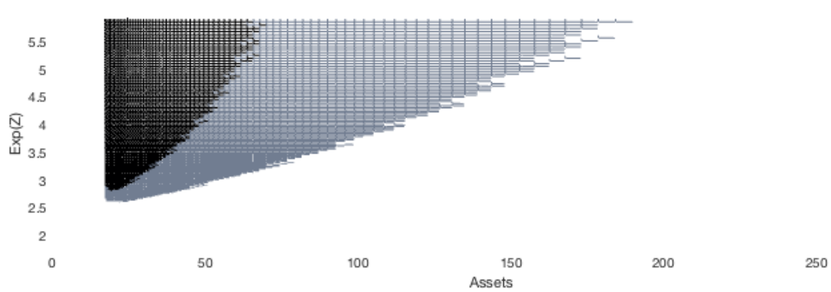
Exogenous changes fed to the model.

IPO choice

The decrease in corporate taxes makes firms less distorted, and hence they can accumulate resources faster and grow more. The decrease in distribution taxes makes the market value of the firm increase notably, so the proceeds at IPO increase. Furthermore, this value increases even more for constrained firms, since now they can access cheaper external funds if they are public.

Figure 2.5 shows the IPO choice in the baseline for a given θ in black (the same as in Figure 2.3), and how this region expands to the grey areas after the changes in taxes. There are two areas that expand notably: firms with low net worth and low z, and firms with large net worth and high z. These two sets of firms are constrained, but before the cost of external funds was too high, so they did not find profitable to do an IPO. When the external cost of funds decrease due to the decrease in distribution taxes, the benefits outweight the costs, they decide to do an IPO and expand their operations by using external financing.

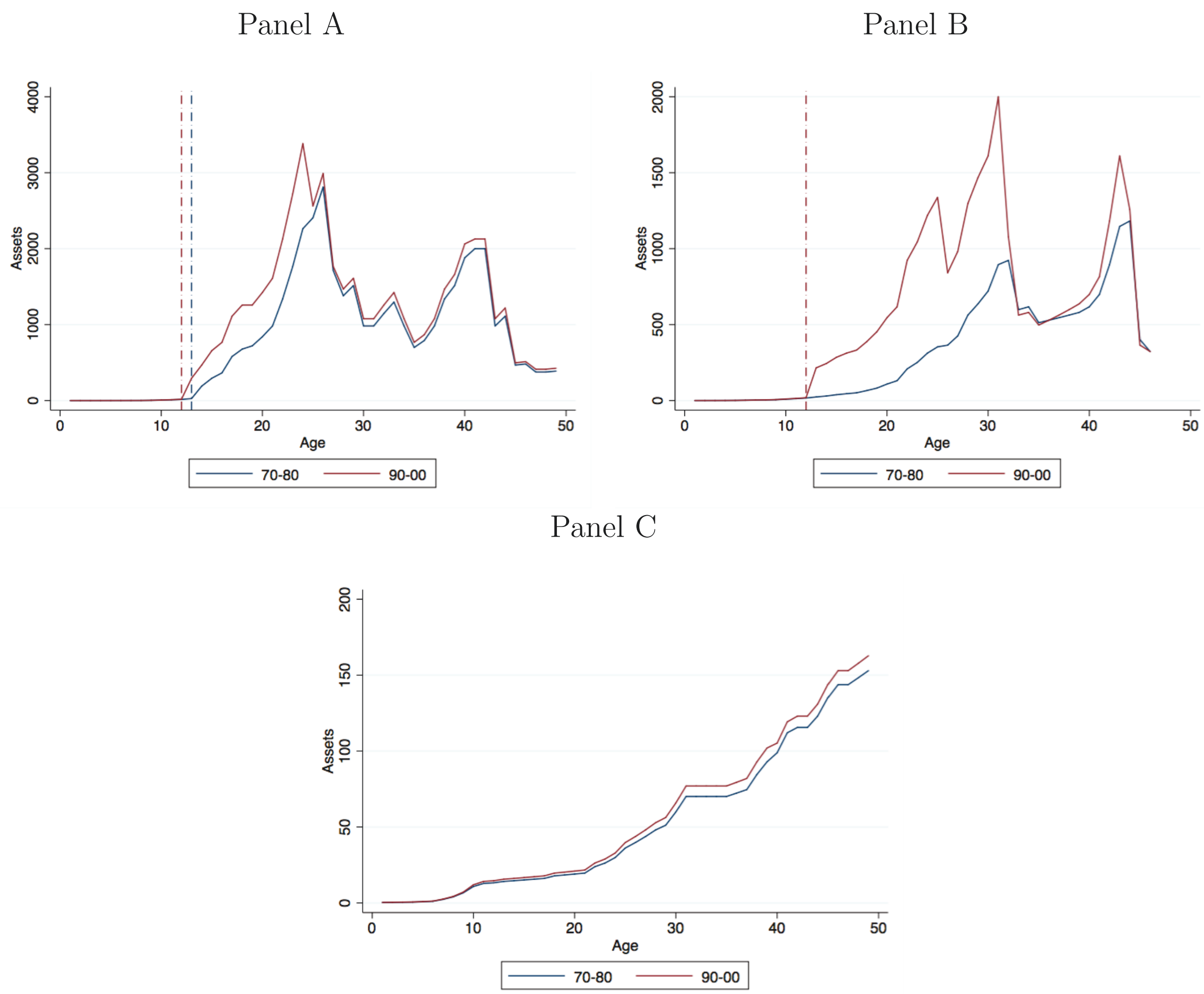
Figure 2.5: IPO choice for given θ, baseline (black) and after policy change (black and grey)



Assets in X axis, transitory shock exp(z) in Y axis, $exp(\theta) = 2.4$ fixed. Firms deciding to do IPO in the baseline in black. Firms deciding to do an IPO after the changes in policies are the black and grey areas.

Firms in this model feature a life cycle: they are born small, learn about their produc-

Figure 2.6: Life cycle and IPO choice of three firms in 70-80 and 90-00



Examples of three different streams of realization of the transitory productivity component z born in the equilibrium of 1970-80 (blue) and born in the equilibrium of 1990-00 (maroon), with θ fixed. Vertical dashed line indicates the age of the IPO, if they go public.

tivity, grow or shrink, until they exit the economy. To exemplify the way changes in the IPO decision can impact the life cycle of firms, and through this affect macroeconomic aggregates, Figure 2.6 depicts the life cycle of three firms of high type θ, as if they were born in the 1970s economy and as if they were born in the 1990s economy. It shows net worth in the Y-axis, and years in the X-axis. They are identical, i.e. have the same productivity type and receive the same stream of shocks, but their policies differ in equilibrium. Even with the same initial distribution of permanent and transitory productivity at entry, firms born in 1990s are larger at entry: since their market valuation increases, the private capital fund is willing to give more funding to initial start-ups.

In Panel A, the firm starts building up its own capital, until it can go public at the age of 13 in the economy of 1970s (vertical dashed blue line). In the economy of the 1990s, the firm is able to do an IPO sooner, at age 12, and therefore can accumulate resources faster. After age 26, the firm in the economy of the 1970s catches up, and then both are unconstrained, responding to shocks in the same manner. Although net worth of the firms in the two economies move paralelly, firm's net worth in the 1990s economy are always higher than those of the 1970s. This is due to two reasons. First, firms can accumulate assets faster since they have more after-tax profits to reinvest. Second, the opportunity cost of holding assets in the firm decreases, so the (uncostrained) firm with low productivity has a higher incentive to hold financial assets inside the firm for precautionary reasons.

Panel B of Figure 2.6 shows the life cycle of a firm receiving a different stream of shocks. In the 1970s economy, this firm never goes public. It cannot afford going public when it is the most constrained, and then loses momentum and ends up never doing an IPO. This firm is very productive, so it will end up accumulating enough resources to be unconstrained at the age of 32 after a series of bad productivity shocks. In the 1990s economy, this same firm does an IPO at age 12. Then, it issues equity, and once it is larger, it is able to accumulate funds much faster. Again, although at the age 32 firms both economies catch up, for twenty years the firm in the second equilibrium has been operating at a less distorted scale.

Finally, Panel C depicts a firm that never does an IPO, neither in the economy of the 1970s nor in the 1990s. Still, even if the firm in the 1990s cannot benefit from the cheaper financing, it can accumulate resources faster, increasing net worth due to the aforementioned reasons. As a result, the amount of net worth in the equilibrium of the 1990s is always above that of the 1970s.

Changes in Composition of Public Firms

Table 2.7 presents the results in the baseline economy regarding changes in IPO choice, composition of public firms, and their behaviour (payout, investment and savings policy). Distribution to sales, equity issuance to sales, investment to sales , financial assets to assets and Tobin's Q are computed as the sum of the numerator (aggregate of all firms in the pool) divided by the sum of the denominator,so that the increases reported in the table are increases of weighted averages[37].

Since distribution and corporate taxes decrease, now it is more appealing to go public, so the share of publicly traded firms increases 32.9%, slightly more than in the data. Smaller and larger firms are willing to go public (see Figure 2.5). How this change reflects in the median and dispersion of employment at IPO depends on the underlying distribution of private firms. In equilibrium, the median size at IPO decreases 23%, while in the data it decreases 43%. Dispersion at IPO, measured as the ratio of the 75th percentile of employment to the 25th, increases 6%, while in the data it increases 62%. This implies that the underlying distribution of private firms deciding to go public is more concentrated in the model than in the data.

There are two opposing forces affecting average size of public firms. Changes in taxes make incumbent publicly traded firms larger on average, ceteris paribus, since they are less distorted and can accumulate resources faster. On the other hand, the selection effect, i.e. smaller firms entering into public, and the increase in wages in general equilibrium make average size of publicly traded firms decrease. In equilibrium, the latter effect dominates, so the average size of public firms decreases 2.2%.

Changes in taxes can explain more than half of the increase in stock market capitalization to GDP, since now there are more public firms, and their market value is higher. Tobin's Q also increases, due to lower misallocation and higher market value of firms.

Most of the change in composition is driven by changes in distribution taxes. Appendix D.1 decomposes the effect of each component by changing only one of the taxes at a time. The changes of only distribution taxes account for 87% of the increase in the share of public firms of the full model, and account for most of the increase in stock market capitalization to GDP and Tobin's Q. However, changes in corporate taxes account for most of the aggregate changes, since it affects directly private and public firms in the economy.

[37] This is done to avoid the large increases in averages driven by a few outliers. Appendix A.1 compares both measures: simple averages and the variables used in constructing these tables.

Table 2.7: From 70s to 90s: Changes in Taxes

	Data 70s-90s	Model
Selection into Public & Composition		
Share public firms	25.0%	32.9%
Avg size public	-28.2%	-2.2%
Median size at IPO	-42.9%	-23.1%
p75 to p25 emp at IPO	62.3%	5.9%
Market cap to GDP	129.7%	74.3%
Tobin's Q	113.5%	20.3%
Behaviour Public Firms		
Fraction firms eq> 0	157.6%	36.0%
Distribution to sales	51%	11.6%
Equity issuance to sales	145.5%	82.0%
Investment to sales	17.8%	0.2%
Financial Assets to Assets	115.3%	15.8%
Volatility emp. Growth public	42.5%	3.6%
Behaviour Private Firms		
Distributions to sales		8.2%
Investment to sales		-4.9%
Financial Assets to Assets		14.8%
Volatility emp. growth		2.1%
Market cap. to GDP		18.1%

Percentage changes from baseline. Distribution to sales,eEquity issuance to sales, investment to sales and financial assets to assets and Tobin's Q are computed as the sum of the numerator (aggregate of all firms in the pool) divided by the sum of the denominator, so that the increases are in weighted averages. Data of public firms from Compustat: changes from 1970-80 to 1990-00. Model: changes from initial steady state to the new steady state introducing exogenous changes from Table 2.6.

Behaviour of Public Firms: Payout, Investment and Savings Decisions.

After the change in taxes from the 70s to the 90s, smaller firms are entering into public, and the share of entrants in the publicly traded firm pool increases, increasing the share of firms issuing equity, and the amount of equity they issue. Furthermore, since the external cost of funds decreases, also incumbents respond more to shocks, issue equity more often, and when they do, they issue more. Hence, the share of firms issuing equity increases 36%[38], and equity to sales rises 82%. The model cannot capture the whole increase in the data, in part because of the absence of adjustment costs in capital or linear-quadratic costs of equity issuance in the model: firms issue all capital needed at once, and do not smooth it over time.

Since firms are less distorted and have more after-tax internal funds to use, they make 11.6% more distributions to sales. While constrained firms invest more (the simple average of investment to sales increases 42.8%), the weighted measure of investment to sales increases only 0.2%. Since wages increase, optimal size of unconstrained firms decrease, hence larger firms invest less (proportionately), making aggregate investment to sales hardly move. The opportunity cost of holding assets inside the firm decreases, since the tax benefit of debt decreases, so unconstrained firms that expect their productivity to grow in the future increase the stock of precautionary savings. This makes aggregate financial assets to assets of public firms increase 15.8%. This is in line with the findings of Sánchez et al. (2013), Chen et al. (2017) or Armenter and Hnatkovska (2017), who find that savings and net financial assets increase during this period, and the latter already points at the importance of taxes for this result. Having a larger buffer of savings and access to cheaper equity, they respond more to shocks to productivity, increasing the volatility of employment growth 3.6%. This mechanism, i.e. changes in taxes as a source of the increase in employment growth volatility, is a new channel explaining the increased volatility observed during this period in publicly traded firms[39].

[38] Realize in the model, firms are either making distributions or issuing equity. Hence, an increase in the fraction of firms issuing equity implies a reduction in the fraction of firms making distributions, in line with the evidence presented in the empirical section.

[39] Other sources found in the literature are increased competition, R&D, changes in corporate governance or financial development. See Comin and Philippon (2005), Comin and Mulani (2009).

Privately Held Firms

Privately held firms benefit from a decrease in corporate taxes in the same way as public firms do. Their decisions are less distorted with lower taxes, so in partial equilibrium (keeping wages constant) firms will optimally be larger. Furthermore, they have more after-tax profits to reinvest, so they can grow faster and distribute more dividends when they do. However, in general equilibrium, wages increase, which implies a lower optimal size. In general equilibrium, there is a reallocation effect towards more productive firms. Firms with low permanent type θ decrease their average size: they were not constrained before, so the reform did not benefit them that much, but they have to pay higher wages. However, firms with high permanent type might increase their size on average, since they can outgrow financial constraints much faster.

The decrease in distribution taxes affect differently private firms, since they do not benefit directly from the cheaper external equity financing while operating. However, they benefit from the policy in two ways. At entry, since the market value of private firms also increases considerably because of the lower taxes, the private capital fund is willing to provide more funds at the early stage. Since the value of doing an IPO increases, this fosters investment for firms that are about to do an IPO. Other than that, the decrease in distribution taxes do not affect their policies.

The last Panel of Table 2.7 shows the effect of the changes in policies in private firms' payout and investment policies. The optimal size of firms is lower on average since there are many firms with low productivity for which wages have increased significantly. Hence, they reach their optimal size faster, investing less on average, and making more distributions. They still increase their financial assets to overall assets, especially those with higher productivity, to be able to respond to the idiosyncratic shocks. Volatility of employment growth of private firms increases since firms are less constrained. The market value to GDP of private firms increases, but less than that of public firms, since there are less private firms (in number), and their market value did not increase as much as that of public firms.

Aggregate Effects

The effects of these changes in behaviour in aggregate variables are depicted in Table 2.8. Financial frictions decrease because external equity issuance is cheaper and because firms have more after-tax profits to reinvest, hence they are less distorted. This makes output increase 3.2%. Aggregate capital, K, increases 9.4%, though less than the increase in assets (net worth) held by firms, A^f, which rises 14.4%. This is a consequence of the increase in savings for '*precautionary reasons*': the stock of net financial assets, i.e. A^f-K, increases. Lower misallocation makes TFP increase 0.9%. Even though aggregate tax receipts decrease 23%, and hence the amount rebated lump-sum to the household, consumption increases 2%, thanks to the rise in profits the household receives from firms and the increase in wages. The model also has implications for the rise in concentration. Autor et al. (2017), among other authors, find there is a widespread increase in concentration from the 1980s until nowadays. The channels I present here, i.e. decrease in corporate and distribution taxes, contributes to the rise in concentration. The mechanism is the same as the one explained in the previous section: the general equilibrium forces induce a reallocation towards more productive firms. In the model, the employment share of the largest 1% (in employment) increases 1.6% after the changes in policies. The average size (again, in employment) of the top 1% to the median size of all firms in the economy, increases 13.7%, pointing at a higher concentration of employment.

Table 2.8: From 70s to 90s: Aggregates

Y	3.2%
K	9.4%
A^f	14.4%
TFP	0.9%
Agg. Taxes	-23.1%
Consumption	2.0%
Emp. Share top 1%	1.6%
Average size top 1% to median size	13.7%

Percentage changes from baseline. Assets of firms is $A^f = \sum_{j \in \{PR,PU\}} \int a(\theta, z, a) d\mu^j$.

Changes in Behaviour of Entrants vs Incumbents

Are changes in the behaviour of public firms led by changes in selection into public, or also by changes in behaviour of incumbent public firms? To answer this question, Table 2.9 separates the changes in behaviour of publicly traded firm into changes in policies of entrants (firms who did IPO in the previous 5 years) and incumbents (those who did IPO more than five years ago), both in the data and the model[40]. The model is succesful

[40]The model results come from a simulation of 10,000 firms born from the stationary distribution of z and a truncated pareto distribution to the types that eventually go public.

in capturing that changes are not only driven by changes in policies of entrants, but also by changes in policies of incumbents. In the model, as in the data, entrants are the ones that increase investment to sales and distributions to sales the most: they are very constrained so they invest more, and since most have lower productivity (lower z), they start making distributions sooner because they reach optimal size faster. Equity issuance by entrants and incumbents increase considerably, since firms are using more external financing.

Table 2.9: Publicly traded: Entrants vs Incumbents, Data vs Model

	Data		**Model**	
	Entrants	**Incumbents**	**Entrants**	**Incumbents**
Equity to sales	6.74	28.1	1.25	1.15
Investment to sales	1.2	0.9	0.8	0.2
Distributions to sales	1.3	0.65	2.9	0.4
Financial Assets to Assets	0.33	0.17	0.77	0.14

Changes in simple averages (ratio of average in 90s to average in 70s) of public firms in the data (left) and the model (right). Entrants are publicly traded firms that did their IPO in the previous 5 years. Incumbents are publicly traded firms that did their IPO more than 5 years ago. Data obtained from a simulation of 10000 born from intial distribution F_z from types θ with a positive probability of doing IPO.

The importance of modelling Private and Public Firms

To shed light on the importance of modelling the distinction between privately held and publicly traded firms for macroeconomic aggregates, I carry out two more experiments. In a first experiment, I set $\xi_0 = \infty$, so that all firms remain privately held at all times. In a second experiment, I set $\xi_0 = \kappa = 0$, so that all firms are publicly traded. Then, I perform the exogenous changes in taxes in these new baselines. The results are depicted in Table 2.10[41]. In the 'only public' baseline, all firms have access to equity; while in the 'only private' baseline, no firm has access to equity after entry, and therefore they are more constrained. When coporate taxes change, in both economies firms are less distorted, and they have more resources to reinvest or distribute every period. When distribution taxes decrease, all the firms in the 'only public' world benefit from this: the decrease acts effectively as a decrease in equity issuance costs, so constrained firms are able to issue more equity, overcoming financial constraints faster, and responding

[41]The baseline results used for comparison are different for each row, with the baseline output of 'only public' being 14% larger than that of 'only private'. However, the focus here is on the *changes* of the policies of interest.

more to the shocks they receive along their life cycle. In the 'only private' world, firms benefit only at entry: the private capital fund is willing to give them higher initial funds. However, other than this, they are not affected by changes in distribution taxes since they cannot issue equity as they operate. Therefore, as expected, the aggregate effects of the changes in regulations in the 'only public' world are higher than in the 'only private' world. Output increases 0.5pp more in a world with only publicly traded firms, and TFP increases 0.2pp more. Since in the 'only private' world firms are more constrained, the decrease in corporate taxes allows them to outgrow their constraints faster. That, together with the decrease in distribution taxes, makes market capitalization to GDP increase more with only private firms[42] than with only public firms.

Table 2.10: Selection effect

	Only Private	**Public & Private**	**Only Public**
Y	2.5%	3.2%	3.0%
K	7.6%	9.4%	8.8%
A^f	12.6%	14.4%	13.7%
TFP	0.6%	0.9%	0.8%
Agg. Taxes	-23.4%	-23.1%	-22.8%
Consumption	1.6%	2.0%	2.0%
Market capitalization (public) to GDP	-	74.3.0%	33.0%
Market capitalization (private) to GDP	34.3%	18.1%	-
Employment Share top 1%	-0.3%	1.6%	0.2%
Average size top 1% to median size	10.1%	13.7%	11.8%

Percentage changes from each respective baseline. Column 'Only private' corresponds to a world where $\xi_0 = \infty$, hence no firm does IPO. Column 'Only public' corresponds to a world where $\xi_0 = 0; \kappa = 0$, hence all firms are public. The rest of the parameters are maintained to those from the baseline depicted in Table 2.2 and 2.4. Column 'Public & Private' correspond to the results from Table 2.7. Assets of firms is $A^f = \sum_{j \in \{PR,PU\}} \int a(\theta, z, a) d\mu^j$.

In the baseline economy with private and public firms, the increase in output and TFP is larger than in a world with only public firms, despite in the former all firms benefit from the change in policy. This is what I call the *selection effect*: new firms that now become public and before decided to remain private can enjoy less financing constraints and respond more to shocks, which amplifies the effects of lower external equity cost. Besides, these firms are among the most productive in the economy (with higher θ),

[42]Nothe this is a *naive* way of computing market valuation, since it assumes the liquidity of the shares of private firms is the same as that of public firms.

so the impact in the aggregates is non-negligible. Note that market capitalization to GDP increases more than twice as much if the selection effect is taken into account: not only existing firms have higher market valuation, but also the pool of public firms is larger. The increase in concentration is much larger in the baseline model. Since the changes in policy benefit more public than private firms and public firms are among the largest and most productive in the economy, public firms grow more in comparison to the rest of the firms, increasing concentration in the economy.

Are direct Equity Issuance Costs important for Changes in Selection?

Up to now, only changes in taxes have been considered. However, average underwriting spreads, which are the direct costs of issuing equity, decreased nearly 2pp in the 1990s, and 5pp points in the 2000s (see Appendix B.2). Hence, this might be one of the main drivers behind the changes in selection observed in the period. To understand whether this is the case, in Appendix D.2 I only change equity issuance costs in the baseline economy. Changes in equity issuance costs observed in the 1990s explain 20% of the increase in the share of publicly traded firms, and only around 3% of the increase in stock market capitalization to GDP. Its macroeconomic impact is small, given that it only impacts the pool of publicly traded firms: output increases 0.1% and TFP 0.03%. Hence, changes in taxes can explain more of the changes in selection at IPO than direct costs can.

2.5.2 What happened after 2000? Exploring other Channels

During the 2000s, distribution and corporate taxes kept on decreasing, although less than in the previous period. However, as shown in Section 2.2, there was a change in the selection patterns of firms becoming publicly traded, which cannot be explained by taxes alone.

In this section I explore other changes in the economic environment that might affect the selection patterns, namely changes in cost of being public, access to borrowing and changes in the idiosyncratic shock process. More precisely, I assess a) if they can explain the 'reversal' in selection, b) their implication for public firms' behaviour, and c) their macroeconomic implications. Although each of these ingredients might contribute to part of the observed changes, I find there is no channel that can simultaneously explain all the patterns observed in the data. Other possible causes for this trend are the increase in M&As[43] and the increase in private capital financing. However, a more complex model is needed for assesing these channels, and hence this is left for future work.

Changes in taxes.

Table 2.11 shows the changes in taxes from the 1970s to the 2000s, and the first column of Table 2.12[44] shows the percent changes from the baseline after changing *only* taxes. Changes in regulation help explain the trends in behaviour of firms. The fraction of firms doing equity issuance increases 51%, and equity to sales increases 110.4%. Although average investment of public firms increase 60%, the aggregate measure of investment to sales decreases slightly (-0.1%), because of the same reasons as before: with wages increasing, optimal size of unconstrained firms decrease, hence larger firms invest less (proportionately), making aggregate investment to sales hardly move. Firms keep a larger stock of savings to avoid going to the costly equity markets. The trends for private firms are also similar to those found in the previous section: they increase distributions and savings stock, but invest less. Output increases 4.7%, and TFP 1.3%, since firms are less distorted and the lowering of financial frictions lowers misallocation. Note the employment share of the largest 1% firm increases 1.8%, therefore increasing further concentration. However, changes in regulations alone cannot explain changes in selection after 2000. They predict a further increase in the share of public firms, and a further decrease on average size of public firms, following the same mechanism explained in the previous section (Section 2.5.1). Market capitalization to GDP further increases, part of this driven by more firms becoming public.

Changes in the cost of being public

During this period there was also an increase in the costs of being publicly traded. The passing of the Sarbanes-Oxley Act of 2002 (SOX), especially Section 404, which imposed additional compliance costs on publicly traded firms, particularly high for

[43] Gao et al. (2013) acknowledges the decrease in the number of IPOs since the 2000s, and blames the changing incentives of small firms to grow by getting acquired by a larger firm, as opposed to operate individually.

[44] Davis et al. (2006) do not have information on the share of publicly traded firms in the 2000s. Hence, I compute this share using Compustat and the BDS. Although in levels the share of publicly traded firms is smaller than in Davis et al. (2006) (0.09% vs 0.12%), the *increase* in the share of public firms from the 1970s to the 1990s is very similar (33.5% vs 25%). Hence, the increase in the share of publicly traded firms is computed from changes from 1970s to the 2000s from Compustat and BDS.

Table 2.11: Exogenous Changes

	70-80 $\rightarrow$	00-08
τ_c	35.4	24.7
τ_d	34.9	17.7

Exogenous changes fed to the model. More details on their computation in Appendix B.1.

small firms, has been argued to be one of the causes for the decrease in IPOs. Indeed, Iliev (2010) exploits a natural quasi-experiment to isolate the effects only due to the Sarbanes-Oxley Act (SOX), and finds that this rule imposed higher real costs to public firms, which were especially high for small firms[45]. Through the lens of my model, this would be translated into a higher ongoing cost of operation κ. Due to the impossibility of accurately measuring the increase in the cost of being public brought by the passing of this law, here I perform a slighlty different exercise. Given that taxes changed, I ask 1) by how much should the fixed cost of being public κ increase, such that the model predicts the same change in the share of public firms as the one we observe in the data?; and 2) is this change consistent with other changes in behaviour and selection of publicly traded firms observed in the period?.

Table 2.12, column (2) depicts the results of changing the taxes to those of the 2000s and increasing the fixed cost of being public. In order to obtain the same increase in the share of publicly traded firms since the 1970s (11.8%), the fixed cost of being public κ needs to increase 68%. This implies that the average size of publicly traded firms increase, which is consistent with the data. However, compared to column (1), the median size at IPO decreases and the dispersion at IPO decreases, at odds with the data. The increase in the cost of being public decreases market capitalization to GDP and Tobin's Q, and decreases the fraction of firms using equity financing. At the aggregate, these higher costs, since they have no productive use (in the model), they decrease output, TFP and consumption if compared to column (1).

[45] Sarbanes-Oxley Act purpose was to improve the quality of financial reporting in order to increase investor confidence, after a series of corporate governance scandals in the US. However, Iliev (2010) finds suggestive evidence that the costs of Section 404 compliance outweigh the benefits.

Table 2.12: From the 70s to the 00s

	Data 70-00	(1) Taxes	(2) Taxes & fixed cost	(3) Taxes & shock process	(4) Taxes & acces to debt
Selection & Composition					
Share public firms	11.8%	35.2%	11.8%	29.3%	33.1%
Avg size public	1.6%	-2.8%	1.1%	7.1%	-3.6%
Median size at IPO	-29.00%	-27.3%	-0.4%	-14.6%	-13.6%
p75 to p25 emp at IPO	470.1%	9.6%	-2.4%	24.8%	5.8%
Market cap to GDP	190.1%	91.4%	57.9%	106.3%	74.8%
Tobin's Q	98.4%	23.6%	19.4%	23.0%	31.2%
Behaviour public firms					
Fraction firms eq>0	159.3%	50.9%	37.8%	96.4%	28.4%
Distributions to sales	61.2%	18.6%	16.5%	27.4%	12.1%
Equity issuance to sales	79.3%	110.4%	132.8%	193.0%	84.4%
Investment to sales	8.1%	-0.1%	-1.4%	8.3%	-7.3%
Financial Assets to Assets	154.9%	26.0%	25.9%	58.6%	8.1%
Volatility emp. Growth public	33.8%	5.4%	5.5%	20.2%	9.2%
Behaviour private					
Distributions to sales		14.4%	-5.8%	22.5%	10.0%
Investment to sales		-7.3%	-7.3%	-2.9%	-12.8%
Financial Assets to Assets		23.0%	22.8%	60.6%	7.1%
Volatility emp. Growth priv		3.2%	3.2%	14.8%	5.8%
Market cap to GDP		27.4%	38.6%	30.9%	21.8%
Aggregates					
Y		4.7%	4.4%	23.3%	8.4%
K		14.1%	13.4%	24.8%	26.0%
A^f		22.8%	22.1%	49.3%	12.5%
TFP		1.3%	1.2%	16.6%	2.2%
Consumption		2.9%	2.5%	22.1%	6.3%
Average size top 1% to median size		20.4%	17.4%	416.6%	37.9%
Emp share top 1%		1.8%	1.0%	6.4%	2.2%

Percentage changes from baseline. Distribution to sales, Equity issuance to sales, Investment to sales and Financial Assets to Asstes and Tobin's Q are computed as the sum of the numerator (aggregate of all firms in the pool) divided by the sum of the denominator,so that the increases are in weighted averages. Data of public firms from Compustat: changes from 1970-80 to 1990-00. Model, Column (1): changes from initial steady state to the new steady state introducing exogenous changes from Table 2.11. Column (2): changes of column (1), increasing κ such that the observed increase in the share of publicly traded firms is the same as in the data, i.e. an increase of 68%. Column (3): changes of column (1), and change in shock process ($\rho_z = 0.85$, $\sigma_z = 0.27$). Column (4): changes in column (1), and changes in borrowing capacity such that b/k in the new equilibrium is 55% larger, i.e. $\phi = 1.74$. Assets of firms is $A^f = \sum_{j \in \{PR,PU\}} \int a(\theta, z, a) d\mu^j$.

Changes in the process of idiosyncratic volatility

To explore this channel, I re-estimate the shock process, but only using the data from 2000-08 (see Appendix B.3 for details). I obtain that the persistence of the shock increases to $\rho_z = 0.85$, and the standard deviation of the shock increases to $\sigma_z = 0.27$[46]. Table 2.12, column (2), shows the percentage change from the baseline if taxes *and* the shock process change. A higher persistence makes firms with good draws of the shock more willing to do an IPO, while discouraging less productive firms from doing an IPO. On the other hand, ceteris paribus, a higher volatility makes firms with low productivity more likely to go public, since they can soon receive a very good shock. Which force wins is determined in general equilibirum, also depending on how the underlying distribution of private firms evolves. Compared to column (1), the share of public firms decreases, and the median size increases, pointing at larger, more productive firms doing IPO, and less productive firms deciding to wait for the IPO. Average size increases, since firms can attain a higher productivity thanks to the increased volatility of the shock. Dispersion of employment at IPO increases further, but still less than in the data. Despite having a lower share of public firms than in column (1), the market capitalization to GDP increases even more. Hence, changes in the idiosyncratic shock process can rationalize the changes in selection *and* the increase in stock market capitalization to GDP, though they cannot fully account for it. The extensive and intensive margin of equity increase considerably: when firms get a very good productivity shock, they can access costly equity issuance to finance investment. Distribution to sales increase, although less than in the data. Financial assets to overall assets increases substantially because of precautionary reasons: since firms can receive a higher draw of productivity, they save internally so that they do not need to access the costly external financing. Volatility of employment growth increases 20%, explaining 63% of the increase in volatility observed in the data.

Private firms are affected in the same way by changes in the idiosyncratic shock process, hence both investment to sales and distributions to sales increase significantly. The

[46]One caveat of this analysis is the selection issue: due to data availability, I assume the process of productivity publicly traded firms and privately held is the same, and estimate it from data from Compustat. If firms entering into public during the 1990-00 have different characteristics, I would be confounding these effects. Davis et al. (2006) find that, while employment growth volatility of publicly traded firms increases in this period, that of privately held decreases. They claim the latter is mainly due to employment shifts toward older businesses account, which can account for 27 percent or more of the volatility decline among privately held firms. In addition, shifts towards larger businesses played a role in certain industries, particularly Retail Trade. This evidence points towards movements of employment to less volatile privately held firms, rather than changes in the shock process. My model currently is not equipped to capture these movements.

only difference is that these firms do not have access to the equity markets, so they take more time to respond to productivity shocks, which makes the volatility of employment growth increase less than for public firms.

The macroeconomic effects are very large: output increases 23%, and capital 25%. Note aggregate assets held by firms increase more than aggregate capital, implying that firms are increasing their savings on the aggregate. This is again in line the findings of Armenter and Hnatkovska (2017), who point at changes in idiosyncratic risk as one of the main drivers of the increase in corporate savings[47]. TFP increases 17%, thanks to the new very productive firms, that face less borrowing constraints. Note that concentration increases, since the share of employment held by the top 1% largest firms increases. It is interesting that this mechanisms helps explain changes in behaviour, and reverses (though only partially) the selection patterns. In the aggregate, changes in regulations and changes in the shock process are complementary: aggregate variables increase more with the two changes together than just summing their aggregate effects changing one at a time[48]. With the changes in taxes, firms can grow faster, they are less distorted, and public firms can finance cheaper, boosting growth of 'lucky' firms that receive a stream of good productivity shocks.

Changes in financial development

In the period studied, there was a process of deregularization in the banking sector in the US, improving access to credit for corporate firms[49]. This view is supported by empirical evidende (Demyanyk et al. (2007), Jayaratne and Strahan (1996)). Changes in access to credit could potentially affect the IPO choice, since bank debt is a substitute of equity financing. Indeed, during this period debt holdings to capital stock increased 55% for publicly traded firms. To capture this, I increase the borrowing constraint parameter ϕ such that, in the new equilibrium, debt to capital of public firms increase 55%[50]. If small private firms benefited more from these changes in regulations, the experiment conducted here could be thought of as a *lower bound* of the effect of financial development. Column (4) of Table 2.12 shows the effect of the changes in taxes and the change in the access to debt.

[47] Sánchez et al. (2013) point at the increase in aggregate uncertainty as one of the main drivers of this increase in savings.

[48] This is done in unreported results.

[49] See Kroszner and Strahan (2014) for a detailed review of the regulation and deregulation of the US banking industry.

[50] This is obtained increasing ϕ 29%. i.e. $\phi = 1.74$. This assumes that privately held firms increased debt proportionally to public firms.

An increased access to borrowing has two opposing effects on private firms. It allows them to grow faster, and hence can do an IPO at a younger age. However, they have more access to financing while being private, so the option of becoming public is less appealing. Comparing column (1) to column (4), less firms are doing IPOs, suggesting the latter force wins, but their median size is larger. However, the dispersion of employment at IPO decreases, wich suggests a larger concentration of firms doing IPOs. Not only public firms benefit from more debt financing, but also private firms. This makes labor demand increase significantly, and hence wages go up, dragging average size of firms down. Remember that in this model debt has a tax advantage. The only reason for the constraint not to be binding is the '*precautionary savings motive*'. Since now we have relaxed the borrowing constraint, firms do not need to save as much, hence financial assets to assets decrease. Stock market capitalization to GDP decreases since output increases more than proportionally than the value of public firms. Tobin's Q increases since the value of firm increses but the stock of net worth they keep is lower. Private and public firms make less distributions since wages increased significantly and use less equity financing. Their volatility of employment growth increases as compared to (1) since they have more access to funds, they are less constrained and can respond more optimally to shocks received.

While constrained and small firms can invest more, because they can borrow more, large firms invest less, since the increase in wages of the general equilibrium makes them optimally smaller. Recall that the values shown in Table 2.12 are weighted, hence investment to sales by private and public firms decrease. In simple averages, investment to sales of publicly traded firms increases 30%. On the aggregate, an increase in access to borrowing further boosts output and aggregate capital, that increase 8% and 26% respectively. Note that assets held by firms increase much less, so net aggregate savings decrease compared to column (1). Having less financial frictions, TFP and consumption increase 2.2% and 6.3% respectively.

2.6 Conclusion

This paper investigates how changes in the economic environment affect asymmetrically private and public firms, their decision to become public (IPO decision), and how these in turn affect macroeconomic aggregates. I introduce privately held and publicly traded firms connected by an IPO decision to an otherwise standard firm dynamics model. Private firms finance with retained earnings and debt. Public firms can also issue costly equity, though they need to pay an on-going fixed cost of operation. Private firms can do an IPO and become public by paying a fixed cost. I calibrate the baseline to match key moments of the distribution of public and private firms in the 1970s. The dynamics of firms around the IPO date are consistent with those found in empirical evidence by Chemmanur et al. (2009).

I first study the decrease in corporate and distribution taxes observed in the data in the period 1970s-1990s. I find the impact of these changes regarding the selection of firms into publicly traded are in line with the data. They predict a stock market boom: an increase of 35.5% in the share of public firms, an increase in the dispersion at IPO, and an increase in stock market capitalization. There are two key mechanisms at play: 1) the differential impact of distribution taxes on firms financing with internal equity (private firms and mature public firms) versus those financing with external equity (constrained public firms); and 2) the lowering of financing constraints of high productivity firms thanks to lower corporate taxes, and hence higher after-tax profits to reinvest. Predicted changes in public firms' policies (equity issuance and dividend payout, investment and savings) are in line with the data.

As private and public firms face different financial frictions, differentiating between private and public firms is important for macroeconomic aggregates. Furthermore, introducing the endogenous IPO choice also matters, since more than half of the increase in stock market capitalization to GDP in the model is driven by changes in selection, i.e. more firms becoming public. Aggregate output and TFP increase more than in an economy with only private or only public firms. Changes in distribution taxes are the main drivers of the changes in IPO decision and payout policy of public firms, but corporate taxes are the ones driving macroeconomic aggregates. The differential impact of taxes on private and public firms accentuates the effect of these changes on concentration, making the employment share of the largest 1% firms increases 1.8%.

Changes in taxes alone cannot explain the changes in selection patterns since the 2000s. I use the model to understand how other changes in the economic environment (namely changes in the cost of being public, the shock process or access to credit) affect firms' behaviour, IPO choice, and macroeconomic aggregates, and try to assess whether they contribute to the 'reversal' in the number of IPOs observed in the data. The most common reason attributed to the decrease in the number of IPOs, i.e. the increase in the costs of being public, can explain the increase in average size of public firms, but it is at odds with other changes in the selection into public, and behaviour of publicly traded firms. A higher access to credit predicts a slight decrease in the share of public firms, but does not contribute to matching other changes in behaviour and selection of public firms. Its macroeconomic effects are important, increasing output and TFP considerably since it allows all firms to reduce their financial frictions. Changes in the idiosyncratic shock process can rationalize the trends in the selection and behaviour of public firms. Furthermore, it has important macroeconomic implications since a higher persistence and higher volatility of the shock process implies there are larger and more productive firms in the economy: output, TFP and concentration increase significantly.

This paper abstracts from many channels that could be potentially important for the results presented, and are important research questions on their own. First, while here I focus on permanent changes in the long run, it would be interesting to see the short-run effects and transitional dynamics of this policy. I am currently working in a follow-up paper studying this issue. Second, investment in innovation rose significantly during this period. R&D is treated differently in the tax code from capital expenditures (it is expensed rather than capitalized), and it is difficult to collateralize, making it very dependent on internal funds and external equity financing (Hall and Lerner (2010)). Hence, changes in taxes faced by firms can asymmetrically impact R&D intensive firms (private and public), interacting with the channels explained in this paper to create interesting dynamics and predictions. Another important change that occurred during this period was the rise of the number of pass-through firms (firms paying only personal income tax on profits). Since the current paper only focuses on C-corporations, I cannot study this interesting channel, i.e. the organizational choice of firms. Introducing this as an endogenous choice in this model is a natural and interesting extension of this paper. First, private firms decide whether to operate as pass-through or C-Corps. Then, C-corporations choose between staying private or becoming public through an IPO. This setting can create interesting dynamics and implications for the organizational choice, and how this impacts output, TFP and concentration.

2.7 Appendix

Appendix A. Data

Appendix A.1. Data Sources

COMPUSTAT North America

I use data from COMPUSTAT North America obtained via WRDS. I use an unbalanced panel of firms from 1970-2008, and will use different subsets of this data in the different exercises, as noted in the main text. I exclude firms whose industry classification is in utilities (SIC codes between 4900 and 4949) or the financial sector (SIC code between 6000 and 6999), following the literature[51]. I also exclude observations reporting a value of acquisitions to assets larget than 5%, since these firms might behave differently. I finally exclude firms reporting negative employment, sales, wages or investment. I keep only firms that are publicly traded[52], i.e. year-observations of firms after the year of IPO, as defined in the next lines. All dollar values are in million dollars (1999 real terms, deflated using the GDP deflator from the U.S. Bureau of Economic Analysis[53]), and all firm-level measures are winsorized at the 1st and 99th percentile. The raw variables I use are the following:

- **Dividends.** Total amount of dividends, other than stock dividends, declared on all equity capital of the company, based on the current year's net income (DVT item). We restrict the analysis to those reporting DVT greater or equal to 0.
- **Distributions.** Total amount of distributions, defined as the sum of dividends (DVT) and share repurchases (PRSTK item).
- **Equity Issuance.** Funds received from issuance of common and preferred stock (SSTK item). I restrict the analysis to those reporting SSTK greater or equal to 0.
- **Assets.** Total value of assets reported on the Balance Sheet (AT item). Realize that in the model, what I call assets is really the net worth of the firm with an

[51] These companies are usually excluded since they face additional regulations and hence might have different payout behavior, and their dividend patterns are quite different from other companies.

[52] Compustat also keeps track of some firms before their IPO, and even some firms that never become publicly traded, as long as they need to file documents to the SEC. Since I want to focus on publicly traded firms, and unfortunately they are not representative of the set of private firms, I exclude these observations.

[53] Accesed at https://www.bea.gov/iTable/iTable.cfm?ReqID=9step=1reqid=9step=1isuri=1

abuse of notation. The model counterpart of total assets, as appear in the balance sheet, is $at = max(a, k)$, and it is the statistic used for all the reported tables.

- **Sales.** Gross sales (SALE item).
- **IPO.** Year of their IPO (IPODATE item). In case this item is missing, I compute it as the year of the first positive observation of closing price (PRCC_F item). This is also the definition of *'Year of entry to public'*.
- **Employees.** Number of company workers as reported to shareholders. This is reported by some firms as an average number of employees and by some as the number of employees at year-end (EMP item).
- **Earnings.** Measured as Operating Income Before Depreciation (OIBDP item).
- **Investment.** Capital expenditures (CAPEX item). The model counterpart is $max\{(a'(x) - a(x)), 0\}/f(x)$[54].
- **Debt.** The item represents debt obligations due more than one year from the company's balance sheet date, as defined by (DLTT item).
- **Cash stock to assets.** The ratio of cash holdings (CHE item) to assets (AT item).
- **Financial Assets.** This item is defined as the sum of cash and short-term investments (CHE item), other current assets (ACO item), and account receivables (RECT item). The model counterpart is $max(a - k, 0)$.
- **Financial Liabilities** This item is defined as the sum of long-term debt (DLTT item), current debt (DLC item), other current liabilities (LCO item) and accounts payable (AP item). The model counterpart is $max(k - a, 0)$.
- **Net financial assets to total assets.** Computed as (Financial Assets-Financial Liabilities)/Assets. The model counterpart is (a-k)/at[55].
- **Market capitalization to GDP.** I compute this statistic as follows. First, I compute market value of a firm by multiplying the net number of all common shares outstanding at the end of the year (CSHO item), times the closing price at the end of the year (PRCC). Then, I compute the market capitalization by summing the market value of all firms operating. Then, I compute the market

[54]Since the shock z' is not known in advance, k' is not known until the next period, so the only investment proxy we have is investment in net worth. Note this measure is also related to savings, since these resources can be used to invest in capital, or just to store as precautionary savings

[55]Note that, in the data, most firms hold financial assets *and* financial liabilities. However, in the model firms hold financial assets *or* financial liabilities.

value to GDP by dividing this last item by nominal GDP obtained from FRED. The market capitalization to GDP computed in this way is very close to that obtained by the Worldbank.

- **Tobin's Q.** Computed as the sum of the market value of equity to the sum of the book value of equity, by year. The model counterpart is the sum of the market value of public firms (V) divided by the sum of assets (a) held by public firms.

In the model, firms are either making distributions, or issuing equity, and optimally never choose to do both at the same time. However, in the data you can find firms making distributions and issuing equity at the same time. Therefore, I need to take a stand when defining the share of firms making distributions, and the share of firms distributing dividends. I define it therefore as:

- **Fraction of firms doing equity issuance.** Ratio of the count of firms issuing equity ($equity_{it} > 0$) and not making distributions ($distributions_{it} \leq 0$), to the total number of firms operating, per year.
- **Fraction of firms making distributions (dividends).** Ratio of the count of firms making distributions (or dividends, i.eq. $d_{it} > 0$) and not issuing equity ($equity_{it} \leq 0$), to the total number of firms operating, per year.

SDC Platinum

I use the Thompson's Securities Data Corporation (SDC) Global New Issues database from 1970-2008. I keep only those observations trading in main stocks markets: NYSE, Amex and NASDAQ (EXCHC codes NYSE Alter, NYSE Amex, NYSE Arca, NYSE MKT, Nasdaq). I restrict the analysis to primary offerings (as indicated by variable SHTYPC), since these are the ones linked to inflows of capital to the firm[56].

Appendix A.2. Additional Empirical Facts about Public Firms

[56] Secondary offerings are offerings of shareholders selling their existing shares, and therefore lead to no inflow of funds to the company.

Table 2.13: More statistics.

	1970-1980			1990-2000			2000-2008		
	Mean	Median	sd	Mean	Median	sd	Mean	Median	sd
Employees	7.90	1.70	18.58	5.67	0.45	17.61	7.99	0.57	21.96
Employment at IPO	1.12	0.35	5.77	2.39	0.20	10.95	3.39	0.25	13.06
Fraction firms eq>0	0.12	0.12	0.03	0.30	0.31	0.03	0.30	0.31	0.03
Equity Issuance to Sales	0.07	0.00	1.03	0.74	0.00	3.53	0.80	0.01	3.89
Fraction dividends>0	0.69	0.68	0.03	0.37	0.36	0.03	0.35	0.36	0.02
Dividends to sales	0.01	0.01	0.02	0.02	0.00	0.05	0.02	0.00	0.06
Fraction distributions>0	0.79	0.77	0.07	0.55	0.54	0.04	0.57	0.56	0.02
Distributions to sales	0.02	0.01	0.04	0.03	0.00	0.09	0.04	0.00	0.11
Investment to Sales	0.07	0.03	0.22	0.14	0.04	0.43	0.15	0.03	0.47
Employment growth	0.03	0.02	0.21	0.04	0.02	0.31	-0.01	0.00	0.29
Voltility emp. growth	0.14	0.12	0.10	0.20	0.16	0.16	0.19	0.15	0.15
Financial Assets to Assets	0.32	0.30	0.15	0.40	0.36	0.24	0.42	0.37	0.25
Net Fin. Assets to Assets	-0.12	-0.13	0.26	-0.04	-0.08	0.39	-0.01	-0.04	0.40

Source: Compustat. Differences in simple means are statistically significant for all, but volatility of employment growth of entrants between 1990-00 and 2000-08, and overall equity to sales bewtween 1990-00 and 2000-08. Averages over a ten year window. Variables are winsorized at 1%. For more information about data construction, see Appendix A.1. Volatility of employment growth computed as in Comin and Philippon (2005).

Table 2.14: Publicly traded firms: entrants vs incumbents.

	1970-1980			**1990-2000**			**2000-2008**		
	Ent.	**Inc.**	**All**	**Ent.**	**Inc.**	**All**	**Ent.**	**Inc.**	**All**
Equity to sales	0.17	0.01	0.07	1.34	0.27	0.74	1.45	0.55	0.8
Investment to sales	0.1	0.05	0.07	0.21	0.09	0.14	0.24	0.12	0.15
Distribution to sales	0.01	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04
Volatility of employment growth	0.18	0.13	0.14	0.24	0.2	0.2	0.25	0.19	0.19

Source: Compustat. Differences in simple means are statistically significant for all, but volatility of employment growth of entrants between 1990-00 and 2000-08, and overall equity to sales bewtween 1990-00 and 2000-08. Averages over a ten year window. Variables are winsorized at 1%. For more information about data construction, see Appendix A.1. Ent. stands for entrants, defined as firms that did their IPO in the previous five years. Inc. stands for incumbents, defined as firms that did their IPO more than five years before. Volatility of employment growth computed as in Comin and Philippon (2005)

Table 2.15: Changes in averages vs changes in aggregates.

	Simple averages		**Aggregates**	
	70s to 90s	**70s to 00s**	**70s to 90s**	**70s to 00s**
Distributions to sales	85.3%	155.1%	51.0%	61.2%
Equity issuance to sales	954.7%	1048.4%	145.5%	79.3%
Investment to sales	113.6%	128.9%	17.8%	8.1%
Financial Assets to Assets	24.6%	30.3%	115.3%	154.9%

Source: Compustat. Differences in simple averages from 1970s to 1990s and 2000s in the left panel. Differences in aggregates - sum of numerator of all publicly traded firms divided by the sum of denominator of all public firms- in the right panel. The changes depicted in the main text are the changes in aggregates, and their model counterpart.

Table 2.16: Employment Weighted Statistics

	1970-1980	**1990-2000**	**2000-2008**
Equity Issuance to Sales	0.01	0.03	0.02
Distributions to sales	0.02	0.03	0.05
Investment to Sales	0.05	0.07	0.07
Financial Assets to assets	0.28	0.28	0.29
Net Financial Assets to Assets	-0.16	-0.21	-0.18

Source: Compustat. Employment weighted means by year then averaged in a 10 year window. Frac. refers to the fraction of firms in each regime. Variables are winsorized at 1%. For more information about data construction, see Appendix A.1. Volatility of employment growth computed as in Comin and Philippon (2005)

Table 2.17: Increase in Averages by Industry.

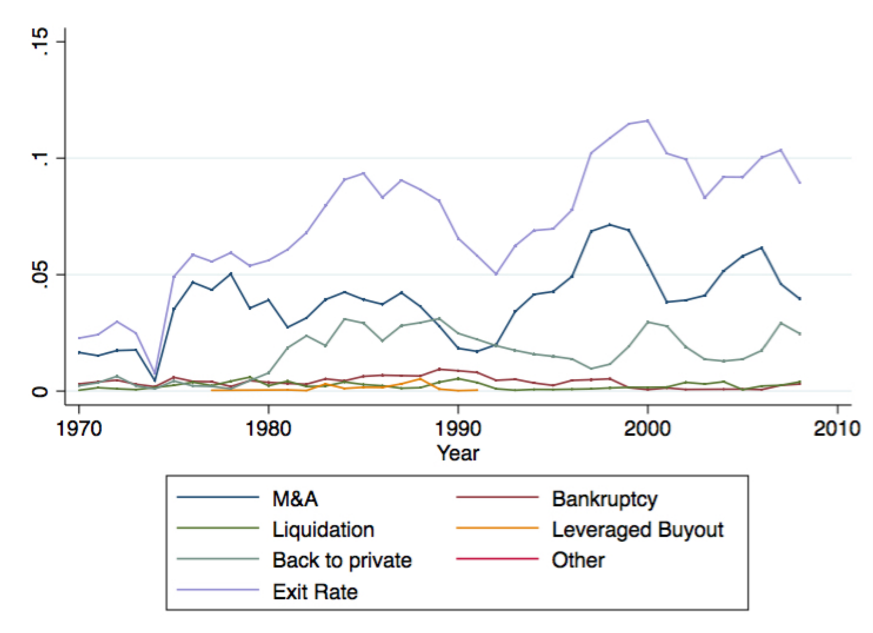
	70s to 90s				70s to 00s			
	Eq. Iss. to Sales	Distrib. to Sales	Invest. to Sales	Frac. eq>0	Eq. Iss. to Sales	Distrib. to Sales	Invest. to Sales	Frac. eq>0
Agricultre, Forestry, Fishing	0.50	1.30	1.59	1.52	-0.63	0.08	0.33	1.54
Mining	0.95	0.67	0.33	1.48	1.89	0.56	0.93	1.51
Construction	10.65	0.16	0.80	1.67	0.57	0.17	0.09	1.72
Manufacturing	19.93	0.73	1.73	1.61	26.51	1.41	2.26	1.63
Transportation, Communications, Electric, Gas, And Sanitary Services	8.75	0.80	0.99	1.58	5.04	1.62	0.75	1.61
Wholesale Trade	6.36	1.00	0.38	1.53	5.35	1.56	0.02	1.52
Retail Trade	14.74	0.65	1.20	1.60	4.72	1.92	0.55	1.61
Services	5.97	1.05	0.54	1.53	3.91	1.90	0.05	1.56

Source: Compustat. Increase in simple means by industry ($mean_x/mean_{70} - 1$). Averages over a ten year window. Variables are winsorized at 1%. For more information about data construction, see Appendix A.1. Eq> 0 refers to the fraction of firms doing equity issuance. Volatility of employment growth computed as in Comin and Philippon (2005).

Figure 2.7: Exit and Entry Rates into Publicly Traded

A: Overall Exit and entry Rates

B: Exit Rates by Reason of Exit



Source: Compustat. Reason of exit as recorded by item DLRSN in the last entry of the firm.

Appendix B. Changes in Economic Environment.

Appendix B.1. Taxes

The most important regulations affecting taxes were the Economic Recovery Tax Act (ERTA) of 1981, and the Tax Reform Act (TRA) of 1986. The former reduced the highest rate to 50%; the latter reduced the marginal tax rate on the highest incomes to 28%. These rate reductions implied a drop in marginal rates paid on dividends, since dividends are taxed as ordinary income. Regarding corporate taxes, increases in depreciation and lower rates adopted in 1981 made the tax rates decrease. The TRA decreased corporate tax rates in 1986, but more restrictive depreciation offset partially this decrease initially, but led finally to lower tax rates in the 1980s and 1990s. In 2003, the US congress enacted the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA), which decreased dividend and capital gains taxation, though this decrease was often seen as a temporary cut.

Table 2.18: Estimated Tax Rates

	Corporate tax	**Distribution tax**
1970-1980	35.4	34.9
1990-2000	28.9	20.0
2000-2008	24.7	17.7

Distribution Taxes

On top of the aforementioned changes in regulations, there were other changes affecting distribution taxes. First, after the enactment of the Employment Retirement Income Security Act (ERISA), there was a substantial increase in the percentage of corporate stock held by non-taxed entities. The share of corporate equities held in tax-exempt entities went from 10% in 1970 to 30% in 2000. Second, there was an increase in share repurchases during this period: using Compustat data, the share of distributions made as share repurchases increased from 13% in 1971 to 53% in 2000. In this section, I try to account for all these changes and estimate a unique tax on distributions, in the spirit of McGrattan and Prescott (2005).

The base data I use is from TAXSIM tables, adjusted with data from the Financial Accounts of the Federal Reserve Board[57], the Investment Company Institute, and

[57] Accessed at https://www.federalreserve.gov/datadownload/Choose.aspx?rel=Z1

Figure 2.8: Distribution taxes 1970-2008.

Compustat.

I start using dollar-weighted average marginal dividend income tax rates for US. These rates are computed by the National Bureau of Economic Research (NBER) using micro data from the Individual Income Tax Models available from the Statistics of Income Division of the Internal Revenue Service, with the TAXSIM model. The TAXSIM model calculates the rates by first calculating the tax liability of each individual income tax return in the sample, then increasing dividend income by 1%.Then, it recalculates the tax liability assuming that other incomes and expenses remain constant. The difference in aggregate tax divided by the difference in aggregate income is the marginal tax rate on the average dollar of dividend income. These rates that include federal plus state taxes. Before 1979, only data for federal taxes is available. To adjust for this in the years 1970-1979, I compute the rates increasing the federal tax by the average ratio of federal plus state to federal tax rates in the years available. This rate is depicted in Figure 2.8 as ADJ 1.

Next, I adjust the tax rate for share repurchases. Share repurchases is a way of distribution to shareholders, by which the firm repurchases its own shares from the market. This is taxed at capital gains rate, rather than personal income tax. The fraction of share repurchases to overall distributions (dividends plus shares repurchases) increased from 13% in 1971 to 53% in 2000[58]. Since my model does not allow for share repurchases, I adjust the distribution tax to account for this computing the yearly average of dividend tax and capital gains tax weighted by each share of the overall distributions. This rate is depicted in Figure 2.8 as ADJ 2.

Finally, I adjust for the share of corporate shares held in non-taxed entities. To do so, I multiply the marginal rates by the fraction of equity held outside of nontaxed accounts. Non-taxed accounts include pension funds, individual retirement accounts (IRAs), and nonprofit organizations. I obtain the fraction of equity held in pension funds from Table L.223 of the Financial Accounts. I also include the corporate equity in pension funds held in the form of mutual funds, with data from Table L.122 and L.117. The fraction of corporate equity in NGOs is obtained from Table L.101a. Finally, I estimate the fraction of equity held in individual retirement accounts (IRA) with data from the Retirement Market of the Investment Company Institute. I use data from IRA Holdings of Mutual Funds by Type of Fund (Domestic equity). The distribution rates after all adjustments are depicted in Figure 2.8 as ADJ 3. The averages for the periods considered are in Table 2.18.

Corporate tax

I estimate corporate taxes by computing aggregate corporate tax rate. To do so, I use aggregate data from NIPA tables from 1970 to 2008. Concretely, I compute it as the NIPA profit tax liability (NIPA table 1.16, line 19) less Federal Reserve Bank profits (NIPA Table 6.16 B, C ,D; line 11) to the NIPA corporate before-tax profits (NIPA 1.16, line 18) less Federal Reserve Bank profits. This is depicted by NIPA effective tax rate in Figure 2.9. This is the rate used in the main text. Although a good measure of the effective tax rate, this decrease could be driven by the increase of S-corps experienced during these decades (which yields a decrease in the numerator, since these firms dont pay corporate tax), rather than a decrease of the effective tax.

[58] This is obtained from Compustat, hence assumes the behaviour regarding share repurchases evolved in the same way for privately and publicly traded firms, which is not necesarilly true, since share buybacks in privately held firms is rare. However, the decrease in distribution taxes is robust to accounting for share repurchases or not (see Appendix B.1). The main reason is that, during the 70-80, the amount of share repurchases was not very high. From the late 1980, although the share of repurchases as a ratio to overall distributions increased substantially to almost 50%, the distribution tax rates and capital gains tax rates were very similar.

To make sure this is not the case, I use different tax estimation techniques and depict them too in Figure 2.9 as a robustness.

I compute the GAAP effective tax rate, which is the tax rate estimated from financial data, using Compustat. I compute it as the ratio of total taxes paid (TXT item) to pre-tax income (PI item) taxes. There are some downsides of measuring taxes this way. Firstly, we would be focusing only on publicly traded firms, so it can paint a misleading picture for the average C-corp in the US. Secondly, it includes items such as deferred taxes, foreign taxes, etc. Thirdly, differences in financial accounting and tax reporting, such as different depreciations methods or certain deductions, that can make GAAP effective tax rates different from the actual effective tax rate that would be computed with tax accounting. Nonetheless, it is a good approximation of how much publicly traded firms effectively pay in the concept of corporate taxes on average. The rates computed by these method are higher than those computed from NIPA, but the trend and the percentage change is very similar, which leads us to think that the decrease in corporate taxes did decrease effective tax rates paid by firms.

Finally, and for the sake of comparison, I also depict the top marginal federal statutory corporate tax rate. Effective tax rates and marginal tax rates convey different - but complimentary- information. Marginal tax rates give the tax rate faced by the last dollar of income earned, while effective tax rates are the average taxation rate for the income earned. Because effective tax rates take into account deferrals, deductions, etc., effective tax rates tend to be lower than marginal tax rates. We observe that top marginal tax rate decreased from nearly 50% in 1970 to 35% in 2000 and 2008.

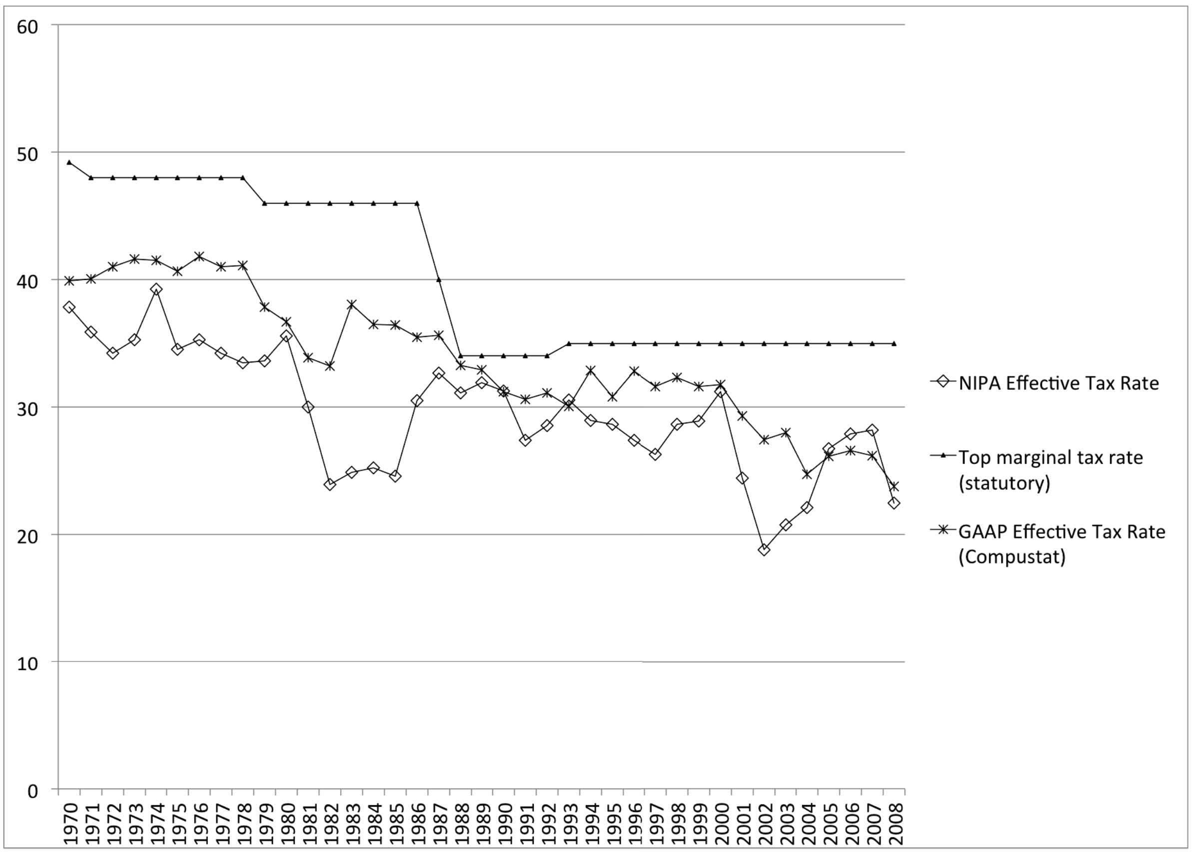


Figure 2.9: Corporate taxes 1970-2008.

Appendix B.2 Equity issuance costs.

There are two types of costs associated with financing via equity: informational costs and transaction costs. Transaction costs are associated with the compensation to underwriters plus all the legal, accounting, and other fees. Informational costs are related to the extra premium that is associated with the bad signal that a firm may transmit to the market when trying to raise funds as well as the deterioration in balance sheet. The latter are very hard to quantify and the number of empirical studies that address the issue is very limited, so the focus here is on the former.

The main piece of regulation affecting equity issuance costs in the period is the Glass-Steagal Act of 1933, which was aimed at the separation of commercial and investment banking, and with this purpose it prohibited commercial banks from underwriting issues. During the 1980s and 1990, this piece of legislation was gradually eroded, until it was completely repealled in 1999. Kim et al. (2008) examine the effect of commercial bank entry on underwriting spreads, and find a decrease in underwriting costs due to the pro-competitive effect.

Following Lee et al. (1996), I compute the total transaction costs of an issue as a percentage of the proceeds as follows:

$$\text{total cost} = GPCTP + EXPTH * 10/PROCDS \tag{2.31}$$

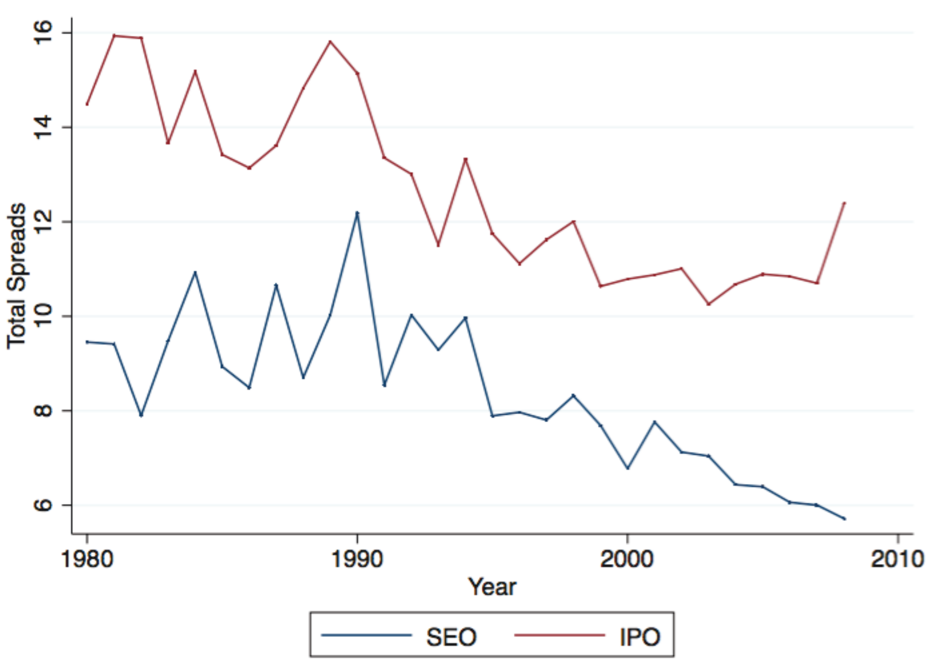
where the first item ($GPCTP$) is gross spreads (management fees, underwriting fees, and selling concession); and the second item ($(EXPTH/1000)/PROCDS * 100$) are other direct expenses (registration fee, printing,legal and auditing costs) as percentage of the proceeds . Before 1980 there are only 3 observations in this dataset, so I take observations until 1985 to take the averages.

Furthermore, there is evidence that equity issuance at IPOs, i.e. the cost of selling the shares to the public for the first time, are higher than those of SEOs (Seasoned Equity Offerings), which are subsequent equity issuances after the IPO. In Figure ??, the evolution on time of total spreads at IPOs and SEOs is shown. This is featured in my model ina reduced form fashion by having to pay a fixed cost at the time of the IPO.

Besides, Lee et al. (1996) make an effort on quantifying part of the informational costs of issuing equity, concretely what is known as 'underpricing', by including the return at the first day of trading as a cost, since it is 'foregone proceeds' that the firm misses. There are several reasons, and a whole branch of finance that studies this phenomenon.

Table 2.19: Summary table

		(1) 1970-1980 Mean	SD	(2) 1990-2000 Mean	SD	(3) 2000-2008 Mean	SD
Overall	Underwriting costs	7.34	1.19	6.69	.85	5.71	.61
	Other Costs	4.43	3.57	3.83	3.66	2.29	3.00
	Total Spread	12.05	5.17	10.71	4.63	7.00	3.74
	Observations	921		4774		4702	
IPO	Underwriting costs	8.46	.45	7.28	.34	6.80	.24
	Other Costs	5.89	3.70	4.54	3.70	3.99	3.33
	Total Spread	14.39	4.68	11.93	4.32	10.79	3.84
	Observations	419		2977		988	
SEO	Underwriting costs	6.41	.71	5.71	.43	5.16	.19
	Other Costs	2.75	2.53	2.61	3.25	1.25	2.02
	Total Spread	9.36	4.34	8.59	4.37	6.47	2.91
	Observations	502		1797		999	



As can be seen in Figure 2.1, the number of publicly traded firms nearly doubled, and the market capitalization increased three times. Employment weighted equity issuance[59] to sales increased almost five times, and employment weighted investment to sales nearly doubled. However, employment wheighted dividends to sales remained fairly constant[60]. It is interesting to note that, while cash dividends were mainly constant, distributions, defined as dividends plus share repurchases, increased during this period. Shares (or buybacks) is when a company buys its own outstanding shares to reduce the number of shares available on the open market. It has become a popular way to make distributions, since these are taxed at capital gains rate rather than personal income tax rate, which has been lower for most of the period studied. Although there are limits to the amount of share buybacks firms can do[61]

Appendix B.3. Productivity shock process and production function curvature.

To estimate the shock process, I use a reduced form estimation approach[62]. I use the Compustat sample from 1970-2008 described in Appendix 2.7 to estimate the curvature of the production function and the parameters governing the stochastic volatility process of the idiosyncratic technology shock. Assuming a Cobb-Douglas[63], sales and gross profits[64] differ up to a constant. The approach used here is similar to that of Gilchrist et al. (2014) and Gourio and Miao (2010). The identifying assumption is that the production function and the productivity shock process for privately held and publicly traded firms is the same.

From equation (2.5), solving for l we have that

$$l = \frac{w}{\exp(z+\theta)k^{\alpha\varrho}}^{\frac{1}{(1-\alpha)\varrho}} \tag{2.32}$$

[59]Equity financing follows a similar pattern.

[60]Fama and French (2001) claim that firms distributing dividends are disappearing, both because of changes in selection of new cohorts becoming public, and because of changes in propensity to distribute.

[61]These are reguated by Rule 10B-18 instituted in 1982, and includes some regulations on the manner of purchase, timing, price and volume.

[62]. Although this estimation may suffer more from endogeneity issues (Olley and Pakes (1996) or Levinsohn and Petrin (2003) methodologies do a better job at this) and does not account for exit, it is widely used in the macro literature.

[63]I will use a production function with parameter $\alpha = 0.3$

[64] In the model, gross profits are $y - wl$. Its empirical counterpart is item OIBDP, operating income before depreciation

Plugging this back, we obtain:

$$f(\theta, z, k) = exp(z+\theta)^{\frac{1}{1-(1-\alpha)\varrho}} k^{\frac{\alpha\varrho}{1-(1-\alpha)\varrho}} \left[\left(\frac{w}{(1-\alpha)\varrho} \right)^{\frac{(1-\alpha)\varrho}{1-(1-\alpha)\varrho}} \right] \tag{2.33}$$

$$f(\theta, z, k) - wl(\theta, z, k) = exp(z+\theta)^{\frac{1}{1-(1-\alpha)\varrho}} k^{\frac{\alpha\varrho}{1-(1-\alpha)\varrho}} \left[\left(\frac{w}{(1-\alpha)\varrho} \right)^{\frac{(1-\alpha)\varrho}{1-(1-\alpha)\varrho}} - w \left(\frac{w}{(1-\alpha)\varrho} \right)^{\frac{(1}{1-(1-\alpha)\varrho}} \right] \tag{2.34}$$

where the term between brackets is a constant in both equations. The empirical counterpart of this equation in logs is

$$logy_{ist} = \beta_0 + \beta_s^k logk_{ist} + u_{ist} \tag{2.35}$$

I use log real earnings and log real capital to estimate Equation (2.35)[65]. I estimate this equation by fixed effects, including a full set of time dummies to capture aggregate trends, such as variations in aggregate productivity, and allowing the decreasing returns to scale parameter to vary by 2-digit SIC code. I obtain the estimated returns to scale from the estimated value of $\hat{\beta}_s^k$

$$\beta_s^k = \frac{\alpha\varrho_s}{1-(1-\alpha)\varrho_s} \rightarrow \hat{\varrho}_s = \frac{\hat{\beta}_s^k}{\alpha - (1-\alpha)\hat{\beta}_{ks}} \tag{2.36}$$

In Table 2.20, I show the average of the estimated the degree of decreasing returns from 2.36, $\varrho = 0.85$. This is in line with the DRS parameter used in the macro literature (Gilchrist et al. (2014),Midrigan and Xu (2014),Jermann and Quadrini (2007)).

I use the residuals from Equation (2.35) to estimate the process of productivity. First, I adjust the error term multiplying it by $e_{ist} = (1-(1-\alpha)\varrho_s)u_{ist}$. Next, I subdivide the sample in three periods, 1970-80, 1990-00, and 2000-08. In each subperiod, I fit an AR(1) to the adjusted error term e_{ist}:

$$e_{ist} = \rho e_{ist-1} + \sigma_z \epsilon_{ist} \tag{2.37}$$

where ϵ_{ist} is iid , and they are drawn from a standard normal distribution. This implies assuming the decreasing returns to scale is constant throughout the period by SIC industries, while the shock process is allowed to change. The results of the

[65] Using log real sales instead as dependent variable gives similar estimates, with sligthly higher persistence and lower variance of the shock.

estimation are presented in Table 2.20[66].

Table 2.20: Estimation of the shock process

	1970-80		**1990-2000**		**2000-08**	
ϱ	ρ	σ	ρ	σ	ρ	σ
0.85	0.8	0.23	0.8	0.28	0.85	0.27

Appendix C. More on the model and its assumptions.

Appendix C.1. Privately Held versus Publicly Traded Firms

There are different advantages and disadvantages in the choice of becoming a publicly traded firm, that firms take into account when deciding whether or not to do an IPO. Becoming publicly traded is usually thought of as a 'one-way' process[67], so firms carefully weigh in the pros and cons of doing an IPO. The main advantages are increased cash to finance investment and long term capital, liquidity for the shareholders, and an increased market valuation thanks to the public information available. The main disadvantages entail higher auditing and reporting costs, principal-agents problems, loss of privacy and short-termism, among others. These different costs and advantages, have been studied extensively and with detail by a thriving branch of the corporate finance literature. In this paper I model them in a very stylized manner, focusing on the trade-off between access to new capital versus higher operating costs. Here, I present evidence supporting these two main features, i.e. that private firms finance mainly with retained earnings and debt; and the higher ongoing operating costs faced by publicly traded firms. I also comment on another implicit assumption made in the model, namely that private firms can only access to private financing at the start-up stage, and what their implications for the model are.

[66] The increase in the standard deviation of the shock observed is robust to using sales as dependent variable, using OLS instead of fixed effects, or instrumenting capital with its lagged value.

[67] Although in practice there are firms that delist and go back to being private, usually through acquisition or leveraged buyout, it can be a difficult and costly process for most firms.

C.1.1 Private firms finance investments mainly with own resources

One of the main difficulties trying to understand the behaviour of privately held firms is finding data that are widely accessible. One of the most widely used datasets for non-publicly traded firms is the Survey of Small Business Finances (SSBF), sponsored by the Federal Reserve Board,that collects information on small businesses (fewer than 500 employees) in the United States. I use the full public dataset for the 2003 SSBF to analyze the sources of funding of investment for privately held firms.

The focus here is on establishing whether privately held firms use external equity issuance as a source of financing for operations. In the survey, only 6% of the firms claim they obtained *any* new equity investment to finance operations. Out of these firms, 88% were issuing equity from individual investors, who were the founding manager 71% of the times. This implies that it is mainly the owner/manager who mainly finances operations, so as long as she does not have deep pockets and she is constrained, changes in the external cost of equity will have very limited impact in the amount of equity raised[68][69].

Table 2.21: Use of external equity by organizational form.

	S-corps	**C_corps**	**LLC filing as C-corps**
Using external equity	5.4%	7.0%	7.0%
From individual investors	91.6%	81.9%	100.0%
From manager/owner	77.4%	59.4%	100.0%

Source: 2003 Survey of Small Business Finances. First row shows percentage of firms using external equity. Second row shows, out of these firms, how many are raising money from individual investors, and out of these, how many are raising the equity from manager/owner is shown in the third row. Responses to the last two questions have many less responses than the previous one.

The previous analysis takes into account all privately held firms, i.e. C-corporations paying corporate and distribution taxes; and S-corporations, LLCs and partnerships

[68] Think of an entrepreneur who solely owns the firm, and can decide how much to invest in his firm k', and how much to consume in the form of dividend from this firm. His budget constraint is $d+k' = \pi(k)+(1-\delta)k$ and his utility is $U((1-\tau_d)d)$. The euler equation is $(1-\tau_d)U'(c_t) = \beta(1-\tau_d)U'(c_{t+1})(\pi'(k_{t1})+(1-\delta))$, so this firm will behave as in the new view, i.e. distribution taxes will not distort his investment decision. If the entrepreneur has access to more than one asset, then distribution taxation will distort her decisions. However, as long as this owner is an individual with no deep pockets and limited access to borrowing, changes in taxation will have little impact in the financing decision of the firm.

[69] Other data also support this. For instance, The Kaufman Foundation surveyed the 5000 fastest growing private firms in US about their source of financing, and found that 67.2% use personal savings; and 51.8% bank loans; and only 6.5% have acces to venture capital, and 7.7% to investment angels.

paying only income taxes on their profits. It is conventional wisdom that C-coporations can raise external equity more easily than pass-through entities. Indeed, there are less restrictions to be a shareholder in C-corporations, which might make it easier for them to raise equity. If we perform the same analysis separating by type of corporation[70], we observe that indeed C-corps obtain more external financing than S-corps. Nonetheless, this difference is minor if compared to publicly traded firms, since in the 2000s almost 26% were financing with equity.

C.1.2 Venture capital, Technolocgical Firms and IPOs

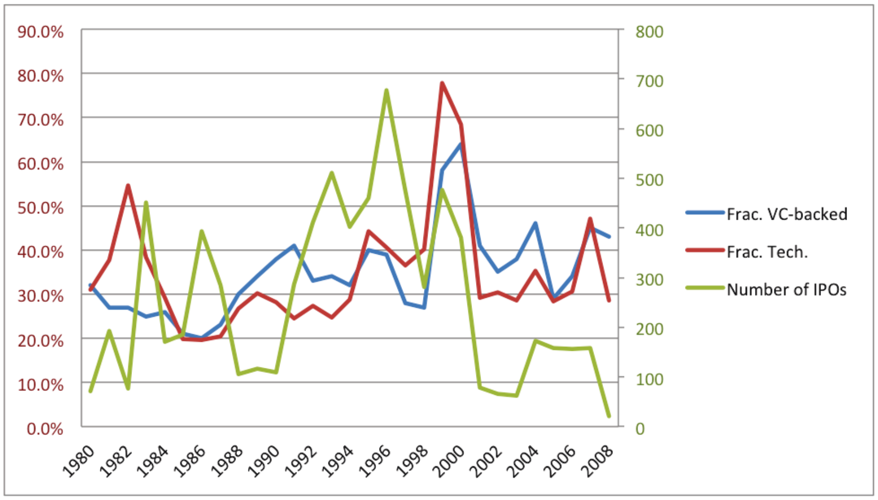
Even though most private firms are not receiving private capital financing, it is the case that firms that end up doing an IPO might receive disproportionately venture capital financing or other private capital funding. For tractability reasons, the model restricts this external financing to be only at the start-up stage. However, if firms receive financing by a venture capital, they might not be constrained at the stage of the IPO, and decide to go public only so that these investors can cash-out their investment. This would mean these firms are not constrained at the boundary of doing an IPO, and hence the model would be overstating the benefits of doing IPOs. If the ratio of venture capital backed firms increased in the period studied, this problem would be even more severe.

Figure 2.10 shows the number of IPOs (in green, on the right axis), the fraction of IPOs that received venture capital financing (blue, on the left axis), and the fraction of IPOs that were technological firms (red, on the left axis). Apart from a spike in 1999 and 2000, technological firms as a fraction of all IPOs was relatively constant slightly below 40%. This casts some doubts on some theories that hypothesize that it is the changes in composition of entrants, i.e. a shift towards more technological firms, that it is driving the changes in behaviour of publicly traded firms. The number of venture capital backed IPOs has increased steadily, from an average of 27% at the beginning of the 80s, to 39% in the 1990s. Hence, understanding the behaviour of venture capital backed firms at IPO is important to understand whether the mechanism at play here is still relevant.

Using data from VentureXpert, I merge it with the panel data I have from Compustat North America, in order to understand whether the behaviour of venture backed firms is different from those that received no venture capital financing. Compustat sometimes

[70] Other forms of corporations, i.e. partnerships, sole proprietorships, etc. had no answers in this question.

Figure 2.10: Number of IPOs, Fraction of VC backed and Technological IPOs.



Source: Ritter's IPO dataset. Number of IPOs (in green, on the right axis), the fraction of IPOs that received venture capital financing (blue, on the left axis), and the fraction of IPOs that were technological firms (red, on the left axis).

retrieves data of firms before doing an IPO, if they have to file for any reason to the SEC, and in the recent years they have information of two years before the IPO[71]. Although not completely representative, it allows to get an idea of what the dynamics around the IPO date are.

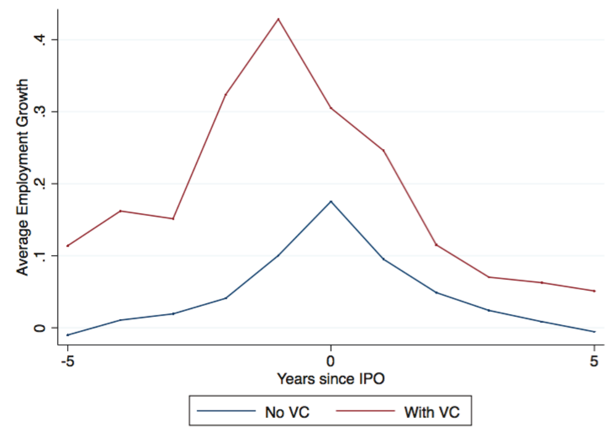
Figure 2.11, Panel A, shows employment growth before and after IPO. As expected, this presents an inverted U shape around the IPO date (this follows directly from the TFP dynamics explained in Section 2.4.4). As it is known, venture capitalist backed firms outperform non venture capital backed firms[72]. However, the dynamics around IPO are very similar, and still follow an inverted U shape. Venture backed firms rely less on debt, as shown in Panel B, and more on equity issuance, as shown by Panel C. Nonetheless, the dynamics of both types of firms are very similar. Firms issue a lot of equity at IPO, using this financing to grow, substituting (partly) debt with equity financing.

[71]Companies that IPO on the NYSE, NYSE Alternext, or NASDAQ are required to file a Prospectus prior to the Initial Public Offering (IPO) date. Data is collected from the prospectus for up to two fiscal years on an annual basis and three years on a quarterly basis prior to the public offering if the data is available from the prospectus. It is possible for a company to have no data prior to the IPO date if the company did not exist prior to the IPO and presents no pro-forma data in the prospectus. Only one year of data was collected from the prospectus prior to 1997. Because of this, I use the whole period studied for the graphs in this section, i.e. from 1970 to 2008, to increase the number of observations prior the IPO.

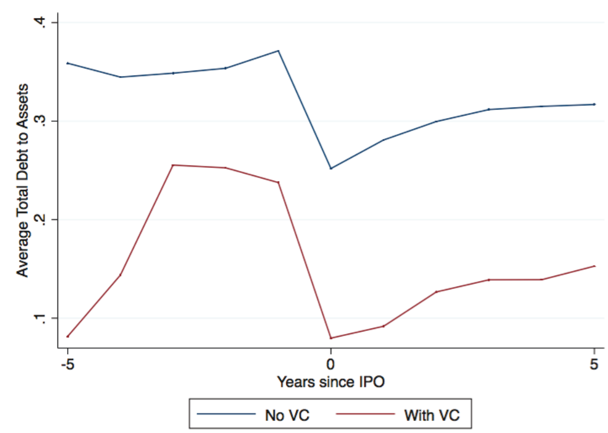
[72]The reasons why this is the case are less clear. See Campbell and Frye (2006)

Figure 2.11: Dynamics around IPO of VC-backed and Non-VC-Backed

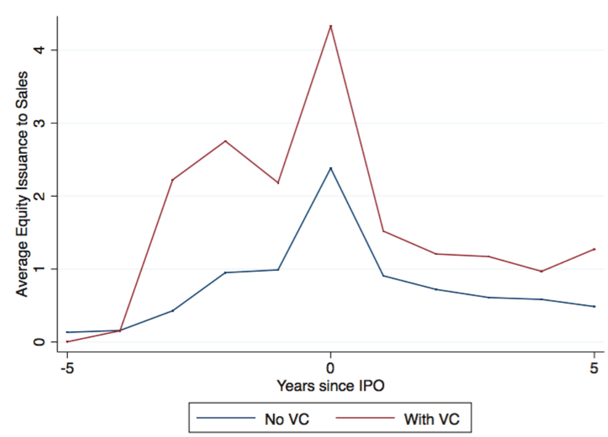
Panel A: Employment growth



Panel B: Debt to Assets



Panel C: Equity Issuance to Sales



Source: Compustat and VentureXpert. Matched data by CUSIP. Year 0 is the year of IPO. Averages by years since/to IPO.

C.1.3 Ongoing costs of operating a publicly traded firm

Public companies are required by the SEC under the Securities 1934 Act to file certain periodic reports to keep the investing public informed[73]. This includes an annual report to shareholders (Form 10-K) providing a comprehensive overview of the company's business and financial condition, including audited financial statements; quarterly reports required for each of the first three quarters of the fiscal year (Form 10-Q), and need to file a report for significant events (Form 8-K) such as an acquisition or disposal of assets, a change in control or bankruptcy, among other important events. Besides, all SEC registrants are required to provide their financial statements and schedules to the SEC and post them on their corporate websites in interactive data format. Furthermore, executive time is often incurred in the preparation of periodic reports filed with the SEC, and more personel needs to be devoted for SEC reporting, financial planning, and taxation, among other activities. According to a survey performed by PWC (PWC, 2012), on average companies incur $1.5 million of recurring costs as a result of being public; 84% of recently public firms hired between one and five new staff specifically to increase their SEC reporting capabilities, and nearly 60% hired new employees for financial planning and analysis. Because of all these, they find that 45% of firms indicated that the costs of being public exceeded their expectations.

C.1.4 The IPO decision

An IPO (Initial Public Offering) is the first time the stock of a C-corporation is traded on a public stock exchange. Although it is modelled in a very stylized manner in this paper, I want to review the main steps followed in the process, and how they relate to my paper.

The main reason for going public are two: raising new equity capital, and obtaining liquidity for the shares of the company. In the model, this is also going to be true: firms will go public to raise new equity, and to 'cash-out' the owner of the private firm[74]. In an IPO, most of the shares offered are primary shares, i.e. new shares that bring new equity entering into the firm; as opposed to secondary shares, i.e. exchange of already existing shares. The latter will imply a capital gain or loss to the owner of

[73] Most privately held firms are exempt of these filings, although there are some exemptions. Any company must file financial reports with the SEC when it exceeds $10 million in total assets and a class of equity securities, like common stock, held by either 2000 or more people; or 500 or more people who are not accredited investors; or when it lists some of its securities on a U.S. exchange.

[74] This would be especially important if private firms were risk averse and cannot diversify

the share (and therefore will be taxed at capital gains rate). The former will imply a dilution of the value of the shares in the company, which will change the value of existing shares, but this gain/loss is not taxed until it is realized, or until the shares are sold by the owners. Because of this, IPOs, unlike selling of a firm in an acquisition, are not directly taxed at capital gains rate.

An IPO starts with the interested firm looking for an investment bank to underwrite the equity issuance. This investment bank will be chosen depending on its reputation, its network, the idustry expertise, etc. Since frictions in this market is not the focus of this paper[75], in my model there are no investment banks, and these are modelled as a mere costly technology' that allows privately held firms to become publicly traded. Once the investment bank is chosen, firms start the due diligence process and regulatory fillings. The investment bank and the firm arrive to one of the underwriting arrangements: firm commitment, i.e. the investment bank purchases whole offer, and then resells it to the public; best efforts, i.e. the investment bank does not commit to sell a certain amount of shares, just acts as an intermediary between the company and the market; or a syndicate of underwriters, where the offering is made by several banks under the leading role of the main underwriting bank, diversifying some of the IPO risks.

After the IPO is approved by the SEC, the issuance date is decided. Before the effective date, the issuing company and the underwriter decide the offer price, and the exact numbers of shares to be sold. In most cases, IPOs are underpriced, i.e. the issuance price is lower than the true value of the share, usually making abnormal high returns on the first day of trading. This phenomenon is widely studied in the Corporate Finance literature. The main reasons proposed for this phenomenon

Appendix C.2. The effect of taxes on optimal decisions

In order to easily see the impact of of taxes on firms' choices, let's first simplify the problem. This analysis builds on Erosa and González (2018). Assume there are only two periods, and privately held and publicly traded are in separate pools, so private firms cannot do IPO and publicly traded firms cannot exit, and that private firms do not smooth dividends, i.e. $\epsilon = 0$. Firms cannot borrow nor lend, so $a = k$, and there is only one type θ. There is no uncertainty, so productivity z is fixed. Firms are born at t=1, with given productivity and capital, operate and make investment decisions.

[75]For papers using search models in this setting, see for instance Lagos and Rocheteau (2009) for an application in over-the-counter markets, or Chen et al. (2015) for a specific application to the IPO market.

In period t=2, firms operate, distribute as dividends everything left and liquidate:

$$W_2(z, k_2) = (1-\tau_d)d_2 = (1-\tau_d)((1-\tau_c)\pi(z, k_2) + k_2)$$

$$V_2(z, k_2) = (1-\tau_d)d_2 = (1-\tau_d)((1-\tau_c)\pi(z, k_2) + k_2) \quad (2.38)$$

At time t=1, the problem of the private firm looks as follows:

$$W_1(z, k_1) = (1-\tau_d)d_1 + \beta\left[(1-\tau_d)d_2\right] \quad (2.39)$$

$$d_1 = (1-\tau_c)\pi(z, k_1) + k_1 - k_2 \quad (2.40)$$

$$d_1 \geq 0 \quad (2.41)$$

Their euler equation reads as follows:

$$\lambda_1 = \beta\lambda_2\left((1-\tau_c)\frac{\partial\pi(z, k_2)}{\partial k_2} + 1\right) \quad (2.42)$$

where λ^d is the multiplier on the non-negativity constraint in dividends, and λ_t the multiplier on the budget constraint. Therefore, capital for next period k_2 is the one that solves:

$$d_2 > 0, \lambda^d = 0 \rightarrow \lambda_1 = (1-\tau_d) \ ; \ \lambda_1 = (1-\tau_d)\beta\left((1-\tau_c)\frac{\partial\pi(z, k_2)}{\partial k_2} + 1\right) \quad (2.43)$$

$$d_2 = 0, \lambda^d > 0 \rightarrow k_2 = (1-\tau_c)\pi(z, k_1) + k_1 \quad (2.44)$$

From this problem, we obtain the following propositions:

Proposition 1 *The shadow value of funds of privately held firms is bounded below by* $(1-\tau_d)$, *i.e.* $\lambda \in [(1-\tau_d), \infty)$

Proof. Follows from Equation (2.43) and (2.44). ■

Proposition 2 *Distribution taxation* τ_d *affects the value of the privately held firm,* $W_1(z, k_1)$, *but does not affect their investment nor payout policies.*

Proof. Follows from Equation (2.43), since $(1-\tau_d)$ appears in both sides of the equation, and from (2.44), since it is not affected by τ_d . ■

Realize this holds even if there is uncertainty, or if we plug back any of the ingredients we simplified. As can be seen from the euler equation, corporate taxation distorts the investment decision: higher τ_c will imply a lower k_2. However, distribution taxation τ_d does not distort the optimal investment decision. Hence, although it affects the value of the firm $W_1(z, k_1)$, it does not affect investment nor the payout policy.

The publicly traded firm problem at time t=1 looks:

$$V_1(z, k_1) = (1 - \tau_d)d_1 - e_1 + \beta\left[(1 - \tau_d)d_2\right] \tag{2.45}$$

$$d_1 - (1 - \xi)e_1 = (1 - \tau_c)\pi(z, k_1) + k_1 - k_2 \tag{2.46}$$

$$d_1 \geq 0 \; ; \; e_1 \geq 0 \tag{2.47}$$

The first order conditions read as follows, where λ_t^d and λ_t^e are the multipliers of the non-negativity constraints of d and e respectively, and λ_t is the multiplier of the budget constraint at time t:

$$\text{d: } (1 - \tau_d) - \lambda_1 + \lambda_1^d = 0 \tag{2.48}$$

$$\text{e: } -1 - (1 - \xi)\lambda_1 + \lambda_1^e = 0 \tag{2.49}$$

$$k_2\text{: } -\lambda_1 + \lambda_2\left((1 - \tau_c)\frac{\partial \pi(z, k_2)}{\partial k_2} + 1\right) = 0 \tag{2.50}$$

Realize that now, the shadow value of funds is bounded above and below:

Proposition 3 *The shadow value of funds of publicly traded firms is bounded below by* $(1 - \tau_d)$ *and above by* $\frac{1}{1-\xi}$*, i.e.* $\lambda \in [(1 - \tau_d), \frac{1}{1-\xi}]$

Proof. Follows from Equation (2.48) and (2.49). ■

This has further implications for the investment and payout policies, and yields to the next proposition:

Proposition 4 *Distribution taxation* τ_d *affects the value of all publicly traded firms,* $V_1(z, k_1)$*, but only affect investment and payout policy of those that are issuing equity, i.e.* $\lambda_1 = \frac{1}{1-\xi}$

Proof. Since in t=2, all firms issue dividends, $\lambda_2 = (1 - \tau_d)$. Hence, if the firm is issuing equity, i.e. $\lambda_1 = \frac{1}{1-\xi}$:

$$\lambda_1 = \frac{1}{1-\xi} = \beta(1-\tau_d)\left((1-\tau_c)\frac{\partial \pi(z,k_2)}{\partial k_2} + 1\right) \tag{2.51}$$

Hence, τ_d distorts the optimal choice of capital k_2. If the firm is distributing dividends, i.e. $\lambda_1 = (1-\tau_d)$, distribution taxes cancel out since they are in both sides of the equality. If $\lambda_1 \in ((1-\tau_d), \frac{1}{1-\xi})$, the firm is reinvesting all the profits, and the investment for next period is given by the budget constraint. Hence, these firms are not distorted by distribution taxes. ■

Realize that publicly traded firms are always distorted by corporate taxes, as privately held firms are.

Life cycle of firms

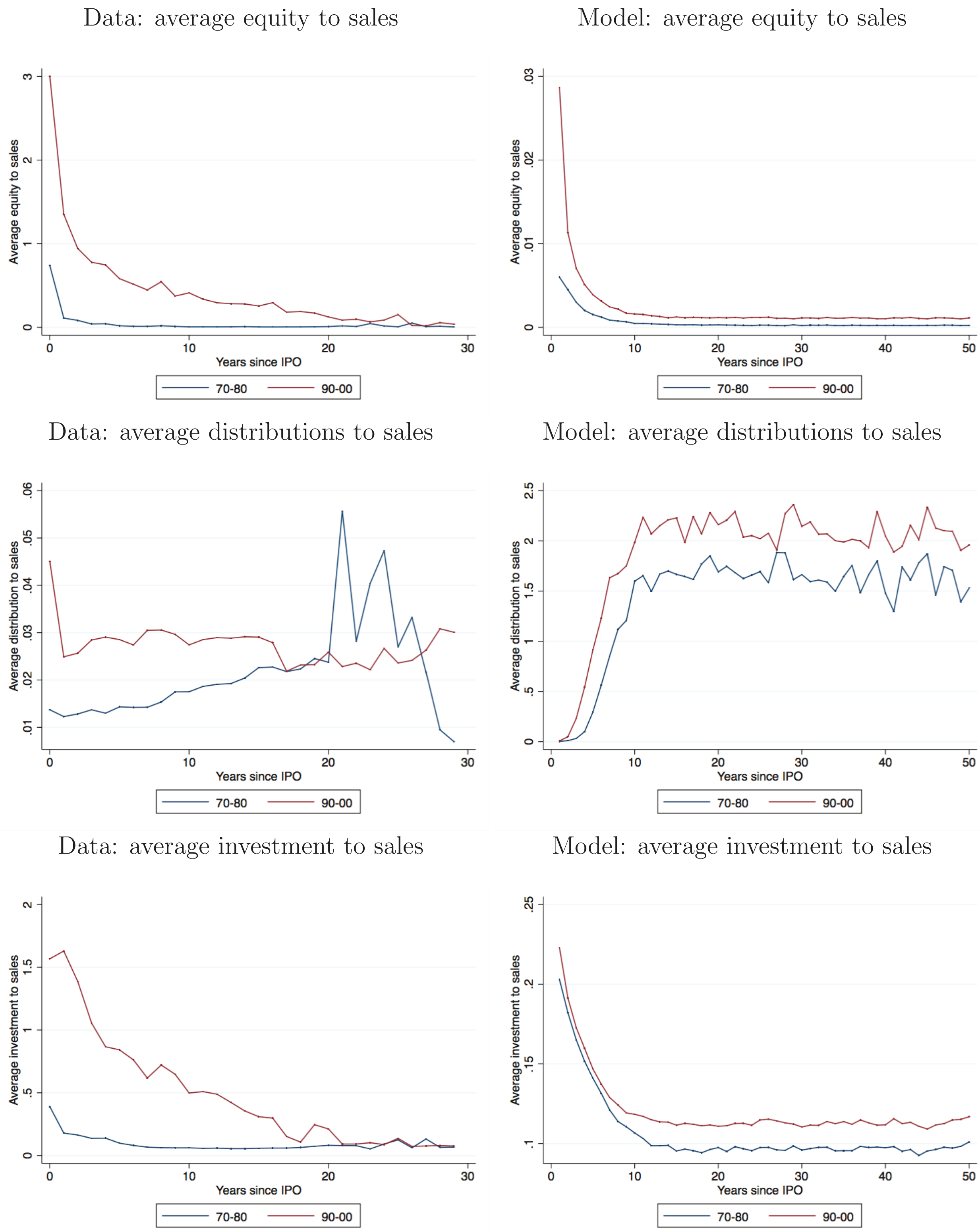
This two period example is simple, since we know for sure the last period the firm is distributing dividends. If there are more periods without uncertainty, the publicly traded firm will start issuing equity, $\lambda = \frac{1}{1-\xi}$. From that period on, firms will reinvest the profits, and start growing, while their shadow value of funds start decreasing, until they reach $\lambda = (1-\tau_d)$, when they start distributing dividends, and distribute dividends ever after. For a more detailed explanation of the effect of dividend and corporate taxes on the life cycle of publicly traded firms, see Erosa and González (2018). Adding uncertainty makes this transition non-linear, i.e. a firm distributing dividends can be issuing equity the following if they receive a sufficiently high positive shock to productivity, and a constrained firm today can distribute dividend the following period if they receive a bad shock.

If firms are privately held, i.e. they start their life raising funds from the private capital fund. From that moment on, they decide whether to reinvest, or to distribute dividends, but cannot raise further external funds via equity issuance. distribution taxation therefore allows privately held firms to raise more private capital funds at the initial stage, but does not affect any optimal policy from then on. Corporate taxes do distort optimal investment choices throughout the life cycle of the privately held firm.

Appendix C.3 Age profiles in the Model and the Data

Figure 2.12 shows average equity to sales, distributions to sales, and investment to sales in the 1970s and 1990s, both in the data and the model. Patterns of equity to sales and investment to sales are very similar to the data: entrants are issuing equity and investing more intensively, and in the equilibirum of the 1990s they are able to finance more and invest more. Distributions to sales increase in the 1990s, though the life cycle pattern is less clear.

Figure 2.12: Policies by years since IPO



Averages by age since IPO.

Appendix D. Further Results.

Appendix D.1. Decomposition of Results

Which of the ingredients, i.e. distribution taxes or corporate taxes, are crucial for the results? To answer this question, Table 2.22 (Columns (2) and (3)) shows the results of computing the equilibrium changing only one of the ingredients at a time, maintaing the rest equal to their baseline value.

A decrease in corporate taxes makes all firms less distorted, increasing investment and aggregate capital. Decreasing only corporate taxes increases output 2.4%, which implies 75% of the growth from the baseline in the equilibrium with all the changes. It improves TFP by 0.5%, since the optimal allocation is less distorted, both for publicly traded and privately held. Not surpringly, since this tax is the most distortive one, it is the one driving most of the results in the aggregates. Regarding selection of firms into public, this tax has relevant effects: the share of public firms increases 11%, while average size of public and median size at IPO decrease 1% and 10%, respectively. Firms have more after-tax profits, hence increasing distributions to sales by 9.4%. Also, when hit by a positive shock, they need more financing and issue more equity, increasing equity to sales by 6.4% and the share of firms issuing equity by 3.6%. Firms having more internal resources to reinvest and willing to grow more when hit by a positive shock, their volatility of employment growth increases 2.9%.

In the next column we find the results of decreasing only distribution taxes. Compared to the rest of the columns, clearly distribution taxes are the ones driving the changes in selection and behaviour of publicly traded firms. Remember, statically, a decrease in distribution taxation acts as a decrease in equity issuance cost if the firm is issuing equity (traditional view), distorting less investment of publicly traded firms growing, while it does not affect firms who are financing marginally with internal resources or are distributing dividends (new view), which were not distorted by this tax in the first place, i.e. privately held firms and mature publicly traded firms. Therefore, it is much more attractive to do an IPO for very constrained firms for two reasons: they can benefit from cheap equity if the become public, and they obtain a higher market price for the firm due to lower distribution taxes. Because of this, the share of publicly traded firms increases 31%, the median size at IPO decreases 19.6%, the dispersion increases 6.7%[76], and equity to sales increases 74.3%. They are also less constrained

[76]Note dispersion at IPO increases more here than in the full model. The reason is that not only the changes in optimal IPO choice matter, but also the underlying distribution of private firms.

Table 2.22: Decomposition and Changes in Equity Issuance Costs

	Data 70-90	(1) **Both Taxes**	(2) **Only** τ_c	(3) **Only** τ_d	(4) **Only** ξ_1 **90s**	(5) **Only** ξ_1 **00s**
Share public firms	25.0%	32.9%	11.1%	30.9%	4.7%	15.7%
Avg size public	-28.2%	-2.1%	-1.1%	-1.7%	-0.2%	-0.7%
Median size at IPO	-42.9%	-23.1%	-9.9%	-19.6%	-3.0%	-8.2%
p75 to p25 emp at IPO	62.3%	5.9%	2.8%	6.7%	1.0%	3.1%
Market cap to GDP	129.7%	74.3%	20.8%	56.9%	4.4%	14.9%
Tobin's Q	115.1%	20.4%	0.0%	20.4%	-0.2%	-0.5%
Behaviour public						
Frac eq>0	157.6%	36.0%	3.6%	31.5%	-1.8%	3.2%
Dist to sales	51%	11.6%	9.4%	2.2%	0.2%	0.3%
Eq to sales	145.5%	82.0%	6.4%	74.3%	4.1%	6.1%
Inv. to sales	36.1%	0.2%	-1.6%	1.6%	0.0%	0.1%
FA to assets	115.3%	15.8%	15.6%	0.6%	0.2%	0.6%
Volatility emp. Growth public	42.5%	3.6%	2.9%	0.7%	0.0%	0.2%
Behaviour private						
Dist to sales		8.2%	10.0%	-3.2%	-1.2%	-2.4%
Inv. to sales		-4.9%	-4.3%	-0.4%	0.0%	-0.1%
FA to assets		14.8%	13.2%	0.9%	0.3%	-0.2%
Volatility emp. Growth priv		2.1%	1.5%	0.5%	0.0%	0.0%
market cap gdp		18.1%	5.3%	8.4%	-1.8%	-5.9%
Aggregates						
Y		3.2%	2.4%	0.9%	0.1%	0.2%
K		9.2%	7.4%	2.0%	0.2%	0.5%
A		14.4%	12.1%	2.1%	0.3%	0.4%
TFP		0.9%	0.5%	0.4%	0.0%	0.1%
Consumption		2.0%	1.5%	0.6%	0.1%	0.1%
Average size top 1% to median size		13.7%	10.4%	4.7%	0.6%	1.2%
Emp share top 1%		1.6%	0.8%	1.0%	0.2%	0.6%

Percentage changes from baseline, making one of the exogenous changes at a time while keeping the rest constant to their baseline value. Data: changes from 1970s to averages in 1990-00. First column (Both taxes) corresponds to the results of the main text, where changes in τ_c and τ_d from Table 2.6 are introduced, i.e. $\tau_c = 28.9\%; \tau_d = 20\%$. Column 2 shows the results in general equilibrium of changing only τ_d to the value of the 1990s,i.e. $\tau_d = 20\%$. Column 3 shows the results in general equilibrium of changing only τ_c to the value of the 1990s, i.e. $\tau_c = 28.9\%$. Column 4 shows the results in general equilibrium of changing only η_1 to the value of the 1990s from Table 2.19, i.e. $\xi_1 = 10.7\%$. Column 5 shows the results in general equilibrium of changing only η_1 to the value of the 2000s from Table 2.19, i.e. $\xi_1 = 7\%$.

and respond more to shocks, increasing the share of firms issuing equity by 31.5%, and the volatility of employment growth 0.7%. Note most of the effect on market capitalization to GDP and Tobin's Q come through this channel: the huge decrease in distribution taxes affects directly the value of the firm, increasing their market value, but does not change the optimal capital and asset holdings of firms that are not issuing equity. However, aggregate results of this change alone are milder, since they affect a smaller fraction of firms: constrained private firms that now become public, and publicly traded firms who want to issue equity. Therefore, output increases only 0.9% and capital stock increases 2%. TFP increases 0.4%, since lower distribution taxes help the most distorted firms, i.e. those with high productivity and low assets, to overcome their constraints. Consumption increases 0.6%. This policy contributes significantly to the increase in concentration.

Appendix D.2 Changes in Equity Issuance Costs

In this Appendix, I change only equity issuance costs from the baseline economy, in order to assess the importance of these on the decision to go public. In the baseline, $\xi_1 = 12\%$. However, these costs have been decreasing in time, as shown in Table 2.19 of Appendix B.2. In the 1990s, $\xi_1 = 10.7\%$ and in the 2000s, $\xi_1 = 7\%$. In Table 2.22, I present thew results of changing only equity issuance costs to the values of the 1990s (Column (4)) and the 2000s (Column (5)).

Even when equity issuance costs are the lowest, they alone imply an increase in the share of publicly traded firms that is half of that implied by changes in taxes, even if these costs affect more directly public firms and the IPO choice. The decrease of equity issuance costs imply a decrease in the average size of public firms, and the median size at IPO, but again way lower than what is implied by the decrease in taxes and what we observe in the data. Note that qualitatively the impact on selection patterns is very similar to that of τ_d sinbce this change works as a 'decrease' of costs of issuing equity, though the latter is much larger, because of two reasons: 1)the decrease in dividend taxes is much larger; and 2)dividend taxes also affect directly the market value of firms, hence the proceeds of doing an IPO,and the size at the creation of the firm. At the aggregate, the impact of changes in equity issuance costs is small, around 0.2%, and TFP increases 0.1%.

Appendix D.3. Sensitivity analysis

Since the persistence parameter ρ, the volatility of the shock σ_z, and the parameter governing decreasing returns ϱ are potentially important for the quantitative results, I carry out sensitivity analysis in this section by changing these parameter values keeping the rest of the parameters constant, but changing also η_0 and κ so that the baseline matches the share of public firms and its employment share, to the extent possible. I perform the same experiment as in Section 2.5.1, i.e. change only corporate taxes and distribution taxes from their values in the 1970s to that of the 1990s in general equilibirum, and show the percent changes from each baseline in Table 2.23. Changes in ρ and σ change the distribution of the underlying transitory shocks, changing the size distribution of firms, and their incentives to do a IPO. The degree of decreasing returns ϱ changes the rents extracted by the owner of the firm (profits) and its optimal size.

Table 2.23: Sensitivity Analysis

		(1) Baseline calibration	(2) $\rho = 0.9$	(3) $\rho = 0.4$	(4) $\sigma = 0.35$	(5) $\sigma = 0.05$	(6) $\theta = 0.9$	(7) $\theta = 0.8$	(8) $\varepsilon = 0$
Parameters	κ	5.5	19.2	0.2	25.2	0.8	142.3	0.8	1.6
	η_0	17.1	59.9	11.1	85.6	5.0	444.9	1.7	9.4
Moments baseline	Share public	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
	Emp share public	0.29	37.76	25.57	32.75	26.04	68.93	10.83	27.05
Micro Statistics Public Firms									
Share Public Firms	25.0%	32.9%	8.8%	41.1%	22.2%	40.4%	7.3%	46.5%	46.4%
Avg size public	-28.2%	-2.1%	-2.4%	-0.2%	-1.2%	-1.7%	-2.4%	-2.6%	-1.9%
Median size at IPO	-42.9%	-23.1%	-22.4%	27.5%	-24.3%	-6.1%	-19.5%	-27.8%	-24.1%
Fraction firms eq>0	157.6%	36%	37.5%	-2.3%	39.9%	3.0%	24.0%	32.8%	35.2%
Distributions to sales	51%	11.6%	9.1%	3.1%	4.6%	8.0%	-15.4%	5.4%	9.4%
Equity issuance to sales	145.5%	82.0%	124.5%	91.3%	100.0%	70.0%	89.4%	81.4%	80.0%
Investment to sales	17.8%	0.2%	0.2%	1.8%	-1.0%	1.8%	-4.7%	2.3%	-1.2%
Financial Assets to Assets	115.3%	15.8%	12.0%	20.2%	8.1%	913.4%	12.1%	19.5%	15.2%
Volatility emp. Growth public	38.6%	3.6%	2.7%	5.3%	1.8%	1.9%	3.7%	3.6%	3.4%
Market cap to GDP	129.7%	74.3%	0.4%	0.9%	0.6%	0.8%	0.4%	0.9%	0.9%
Aggregates									
Y		3.2%	3.3%	2.8%	3.5%	2.4%	4.3%	2.7%	2.9%
K		9.2%	9.8%	8.3%	10.0%	8.4%	10.6%	8.5%	8.4%
TFP		0.9%	0.9%	0.7%	1.1%	0.3%	1.3%	0.7%	0.8%
Consumption		2.0%	2.1%	1.6%	2.2%	1.7%	2.9%	32.9%	2.6%

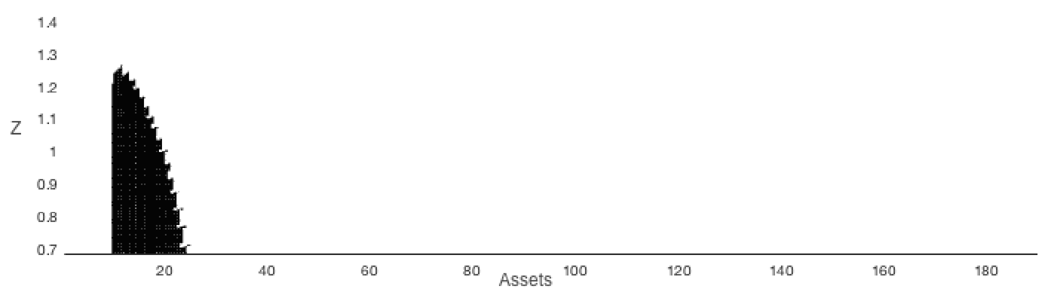
Percentage change of changing exogenously taxes as depicted in Table 2.6 from each baseline. Each baseline is computed with the same baseline parameters from Table 2.2 and Table 2.4, but the parameter on top, and κ and ξ_0 are recalibrated to match the baseline share of public firms and employment share of public firms, to the extent possible. Distribution to sales, Equity issuance to sales, Investment to sales and Financial Assets to Asstes are computed as the sum of the numerator (aggregate of all firms in the pool) divided by the sum of the denominator, so that the increases are in weighted averages.

Persistence of productivity shock

Persistence of the productivity shock matters for the IPO decision. If persistence is high, the firm expects to maintain the draw of productivity for a long time, and hence will decide to do an IPO when the shock is high. If persistence is very low, the firms might decide to do an IPO when the shock is low, since I expect my productivity to grow very soon.

When shocks are very persistent (see in Table 2.23 the experiment with $\rho = 0.9$), the increase in the number of publicly traded firms is lower, since only firms with very productive shocks decide to do an IPO. Average size of publicly traded and median size at IPO decrease. Equity to sales increases significantly, 124.5%: in the occurrence of a positive shock, firms want to raise more capital in order to invest more, since they expect the shock to be more persistent. Changes in taxes have a larger positive effect on the aggregates if the shock is persistent. Firms that expect the shock to be persistent will expand more and benefit more from the policies, that make them less distorted and with cheaper access to external equity.

Figure 2.13: IPO choice, baseline low ρ



When shocks are not persistent (see in Table 2.23 the experiment with $\rho = 0.4$), firms are less willing to go public. If IPO costs ξ_0 and ongoing costs κ are maintained as in the previous case, no firm is willing to go public. This is because if you get a high productivity draw, it is less likely that you keep it, but you still have to pay the fixed cost of operation κ. This makes the IPO choice map looks exactly the opposite: firms with relatively low assets and low productivity will do an IPO, since they expect their productivity to grow soon due to the low persistence. They have low assets, so by going public they can build up capital foreseeing an increase in their productivity. This makes the median size at IPO increases, which is at odds with the data, since now the marginal firms deciding or not whether to do an IPO have higher productivity z, and hence will be larger in size. The fraction of firms doing equity issuance decreases

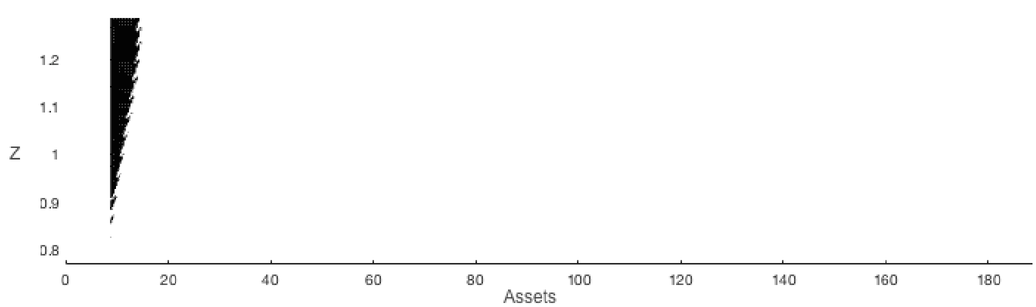
2.3%: since firms doing IPO are not very constrained, they have time to build up internal assets and need external financing less often. However, the intensive margin, i.e. equity to sales, increases 91.3%. The rest of the changes are qualitatively similar to the baseline. Figure 2.13 shows the IPO policy in the baseline with low persistence of the productivity shock.

Volatility of productivity shock

In Table 2.23 I show the results of a baseline model with high volatility of shocks (column (4), $\sigma_z = 0.35$) and low volatility of shocks (column (5), $\sigma_z = 0.05$). Realize that changing the volatility of the shocks changes the employment share of publicly traded significantly[77] when shocks are high, firms' productivities are able to spread more, and since publicly traded firms are less constrained, they will be able to employ more people and get therefore a higher share of employment.

In the baseline, increasing the volatility of shocks makes it more appealing to do an IPO, since the shocks they receive are larger and hence are more likely to be financially constrained. Because of this, the fixed cost of IPO ξ_0 and the fixed cost of operation κ need to increase, so that the share of publicly traded firms is kept constant at 0.12%. Exactly the opposite occurs when the volatility is low: firms again are less willing to do an IPO, since the improvements in productivity are lower, and hence they need less external financing. The IPO choice in the baseline for low volatility is depicted in Figure

Figure 2.14: IPO choice, baseline low σ



The effects of the policy are qualitatively similar in the two cases, but differ quantitatively. Regarding selection, regulations in both worlds have similar results: they increase the number of publicly traded firms, decrease the average size of public firms

[77]This cannot be fixed only with changes in ξ_0 and κ. A full recalibration would be needed to match the 0.29, especially the tail of the pareto parameter η

and decreases median size at IPO. Regarding payout and financing policy, changes in regulation affect signifanctly more in a world with high volatility of shocks. Since the decrease in taxes makes it cheaper to finance externally, firms facing high idiosyncratic shocks are able to adjust better, increasing equity to sales and the fraction of firms distributing dividends and the volatility of employment growth. This makes that changes in regulations have larger macroeconomic impact than in a world with low volatility, increasing more aggregate output, TFP and consumption. Note that financial assets to assets does not increase that much in a world with high volatility, since the base level of stock of savings was already high. In the world with low volatility, it seems the increase is huge, but this is only due to the fact that in the baseline the level is very close to 0, so even a minimal increase makes this statistics increase a lot.

Degree of decreasing returns to scale

In Table 2.23 I show the results of a baseline model with higher parameter of decreasing returns to scale (column (6), $\varrho = 0.9$) and a lower parameter (column (7), $\varrho = 0.8$). For the parametrization considered, an increase in ϱ implies higher optimal size. Because of this, an increase in ϱ implies a huge increase in the employment sare of publicly traded firms, since the most productive firms are going to be larger now. Since they are larger, the fixed cost of operation and the fixed cost of IPO need to increase. However, an increase in ϱ implies less profits,which makes going public less attractive. Hence, although in levels they are larger, the fixed cost of operation as a percentage of average output, and the fixed cost of IPO as a percentage of the initial value of the firm, decrease substantially in the baseline with high ϱ. Changes in micro statistics are very similar to those previously reported. Aggregate results of the policy are the largest with high ϱ, since it eases financial constraints and allows firms to grow faster.

Dividend smoothing parameter

Finally, as a robustness, I study the effects of the policy when $\varepsilon = 0$, meaning that privately held firms are free to reinvest all their profits when they are growing. When this happens, the labor share of public firms decreases, since now private firms can grow faster and hence employ a larger share of the population. The share of publicly traded firms is more responsive when this is the case. For the rest of the changes in selection and behaviour of public firms the results are very similar to the baseline, qualitatively and quantitatively. Aggregate results of the tax policy are lower than in the baseline, since in the baseline doing an IPO allows firms to overcome the inneficiencies of being private, modelled in the form of ε, while in this experiment with $\varepsilon = 0$ there are no such inefficiencies.

Appendix D.4. Adding a full set of taxes.

During the 1970s to the 1990s, there were also changes in income and capital gains taxes, that the model in the main text is abstracting from. One reason for this is that these tax did not change as much as corporate and distribution taxes. Another reason is the difficulty of modelling correctly capital gains tax, even more so when modelling private firms. In the US, capital gains are taxed upon realization (i.e. when the asset is sold and the gain of the whole holding period is *realized*), as opposed to accrual (every period based on the gain of that period). Modelling capital gains tax upon realization would complicate the model very much, and it outside the scope of this paper. Other authors have made the simplication assumption that the tax is paid upon accrual (for instance, Gourio and Miao (2010)), which makes the analysis much simpler. Here I follow their methodology to model the capital gains tax, so the interested reader can find more information about the modelling assumptions in their paper.

The problem of the private firms becomes:

$$W(\theta, z, a) = \max_{\{d,a'\}} \frac{(1-\tau_d)}{(1-\tau_g)} d + \frac{1}{1 + r\frac{(1-\tau_i)}{(1-\tau_g)}} (1-\varsigma) E\left[max\{W(\theta, z', a'), W^{IPO}(\theta, z', a')\}\right]$$

$$\text{s.t. } d + a' = (1-\tau_c)\pi(\theta, z, a) + a \tag{2.52}$$

$$d \geq \varepsilon(1-\tau_c)\pi(\theta, z, a) \tag{2.53}$$

The problem of the public firm becomes:

$$V(\theta, z, a) = \max_{\{d,e,a'\}} \frac{(1-\tau_d)}{(1-\tau_g)} d - e + \frac{1}{1 + \frac{\rho}{(1-\tau_g)}} (1-\varsigma) E\left[max\{V(\theta, z', a'), 0\}\right]$$

$$\text{s.t. } d - e + \xi(e) + a' = (1-\tau_c)(\pi(\theta, z, a) - \kappa) + a \tag{2.54}$$

$$d \geq 0; e \geq 0 \tag{2.55}$$

where $\rho = (1-\tau_i)r$[78] is the rate of time preference of the investor (i.e. the representative

[78]The rate of time preference ρ is set to 0.04, and in equilibirum the risk-free rate is such that $\rho = (1-\tau_i)r$

household).

The value of doing an IPO is:

$$W^{IPO}(\theta, z, a) = V(\theta, z, a - \xi_0) - \tau_g(V(\theta, z, a - \xi_0) - W(\theta, z, a)) \tag{2.56}$$

Table 2.25 shows the changes in taxes from the calibrated baseline, to the new equilibrium in the 1990s. I recalibrate the model with the full set of taxes in the new baseline to match the employment share of public firms, the share of public firms in the overall economy and the employment share of the top 2%. The rest of the parameters are the same as in the baseline economy. The calibration and parameter values are showed in Table 2.24.

Table 2.24: Calibration with full set of taxes

	Data	**Model**	**Parameter**	**Value**
Employment share public firms	0.29	0.29	κ	8.2
Share public firms	0.12	0.12	ξ_0	42.8
Emp. share of top 2%	0.61	0.63	η	3.35

Table 2.25: Exogenous Changes in Taxes and equity Issuance Costs

	1970s	**1990s**	**Source**
τ_d	0.349	0.2	TAXSIM (adjusted)
τ_c	0.354	0.289	NIPA
τ_g	0.224	0.268	TAXSIM
τ_i	0.319	0.283	TAXSIM

Table 2.26 shows the results for changes in selection and behaviour of public firms. Results are qualitatively very similar to the ones presented in the main text. The share of public firms increases slightly more, while average size of publicly traded firms decreases. This is because, on top of the forces driving the decrease in average size explained in the main text, an increase in capital gains taxation implies a lower optimal size (see Erosa and González (2018)). The dispersion at IPO increases more, explaining about 20% of the increase in the data. Stock market valuation to GDP increases less, since firms' optimal size is lower, and the market value of firms decreases due to an increase in the discount rate of the value of the firm brought by an increase in τ_g. since their optimal size is smaller, the increase in the use of equity financing is lower, and

holds.

so is investment. Note that corporate savings, measured by financial assets to assets, increases only 0.9%, as compared to 16% in the baseline experiment and 113% in the data. The main reason for this is because in equilibrium risk-free rate decreases to compensate for the decrease in the personal income tax. This implies that the return on savings decreases, and debt is cheaper, which makes the '*precautionary savings*' decrease. Because of all this, firms are more constrained than in the baseline results, and aggregates increase less. Output increases 2.5% (versus 3.2%), and TFP 0.7% (versus 0.9%), and concentration of employment increases less.

Table 2.26: 1970s to 1990s: Changes in Selection and Behaviour of Public Firms

	Data 70-90	**Baseline Taxes**	**Full set of Taxes**
Selection & Composition			
Share public firms	25.0%	32.9%	35.1%
Avg size public	-28.2%	-2.1%	-4.3%
Median size at IPO	-42.9%	-23.1%	-26.5%
p75 to p25 emp at IPO	62.3%	5.9%	11.9%
Market cap to GDP	129.7%	74.3%	66.3%
Tobin's Q	115.1%	20.4%	22.5%
Behaviour public			
Frac eq>0	157.6%	36.0%	37.2%
Dist to sales	51%	11.6%	11.5%
Eq to sales	145.5%	82.0%	75.7%
Inv. to sales	36.1%	0.2%	-0.9%
FA to assets	115.3%	15.8%	0.9%
Volatility emp. Growth public	42.5%	3.6%	1.0%
Behaviour private			
Dist to sales		8.2%	6.0%
Inv. to sales		-4.9%	-4.8%
FA to assets		14.8%	1.7%
Volatility emp. Growth priv		2.1%	1.0%
market cap gdp		18.1%	12.9%
Aggregates			
Y		3.2%	2.5%
K		9.2%	7.5%
A		14.4%	7.9%
TFP		0.9%	0.7%
Consumption		2.0%	1.8%
Average size top 1% to median size		13.7%	6.4%
Emp share top 1%		1.6%	0.5%

Percentage changes from baseline. Column (1) depicts the percent changes from the baseline, as outlined in Section 2.5.1, i.e. the model calibrated as explained in Section 2.4, and changes only corporate and dividend taxes in general equilibirum to the values of the 1990s. Column (2) shows percent changes from a baseline with a full set of taxes calibrated as explained in this Appendix. The exogenous changes in taxes are the ones from Table 2.25. Distribution to sales, Equity issuance to sales, Investment to sales and Financial Assets to Asstes are computed as the sum of the numerator (aggregate of all firms in the pool) divided by the sum of the denominator, so that the increases are in weighted averages. Data of public firms from Compustat: changes from 1970-80 to 1990-00. Model: changes from initial steady state to the new steady state introducing exogenous changes.

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